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The relationship between neighbourhood-level and family-level factors and sleep problems among children and youth

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Abstract

There is little research on the effects of neighbourhood factors on child sleep outcomes. No study to date has investigated the interactive effects of neighbourhood and family socio-economic characteristics (SECs) on child sleep outcomes. This study aimed to fill this gap. Secondary data analyses were completed on two samples (children and youth) from the 2014 Ontario Child Health Study, a cross-sectional, province-wide sample of 10,802 children aged 4 to 17. Multi-level modeling was used to assess the relationship between child- (e.g., age), family- (e.g., negative parenting) and neighbourhood-level factors and their relationship to sleep outcome variables: problems falling asleep, problems staying asleep, weekday sleep duration and weekend sleep duration. The interactive effects of family and neighbourhood poverty significantly predicted one sleep outcome variable (child weekend sleep duration) in the current study. Different levels of SECs may interact to influence child sleep and relate to sleep outcomes differentially across development.

Keywords

Children, adolescence, sleep, neighbourhood factors, family factors.

Summary for Lay Audience

Sleep problems in childhood are related to a variety of negative outcomes such as behavioural problems, poor school performance and poor physical and mental health. A number of child (e.g., age, mental health problems) and family (e.g., parenting, single-parent status) influences have been found to be important to child sleep problems. Recently, researchers have found a relationship between the make-up of a neighbourhood (e.g., poverty levels) and child sleep problems. No study to date has looked at how family and neighbourhood poverty interact with each other to influence aspects of child sleep (e.g., problems falling asleep, problems staying asleep, weekday sleep duration, weekend sleep duration). Information on sleep and neighbourhood features was collected on a representative group of children and adolescents from Ontario. We found that children in high poverty neighbourhoods with family poverty, and children in low poverty neighbourhoods with no family poverty had the lowest weekend sleep durations. We did not find this relationship for adolescent sleep problems or sleep durations. We also found that children living in neighbourhoods with break-ins and assault were related to more problems falling asleep. This research gives us important information into how neighbourhood features relate to sleep health. Overall, neighbourhood factors may relate differentially to aspects of child sleep and may relate to sleep problems in a different way from childhood to adolescence. Neighbourhood features may be related to important differences in sleep health for children with family poverty also living in high poverty neighbourhoods.

Co-Authorship Statement

This project was completed under the supervision of Dr. Graham Reid.

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Chapter 1

1. General Introduction

About 40% of children (4-11 years old) experience sleep problems at some point during childhood and adolescence (age 12-17 years old; Owens, 2005). Common sleep problems include bedtime difficulties (e.g., going to sleep), night wakings, and poor/excessive sleep duration (Meltzer, 2017; Meltzer & Mindell, 2014). Some studies also include excessive daytime sleepiness and poor sleep efficacy as problems (Kliewer & Lepore, 2015; Troxel et al., 2017). Sleep problems are associated with behavioural problems, poor school performance, and poor physical and mental health (Armstrong et al., 2014; Coulombe et al., 2010). Good quality and quantity sleep is associated with improved memory, learning, attention and behaviour (Schotland & Sockrider, 2017). Therefore, sleep is implicated quite broadly in children's social and emotional development. However, no study to date has investigated the interactive relationship between neighbourhood- and family-level poverty on child sleep outcomes. This study will add to the literature by examining the relationship of neighbourhood-level factors to child and youth sleep outcomes above and beyond previously identified important risk factors in a Canadian sample.

The current study presents a secondary analysis of data collected in a recent epidemiologic study examining risk and protective factors for mental health – the 2014 Ontario Child Health Study (2014 OCHS; Boyle et al., 2019a). Using the data from this study we assessed neighbourhood-, family- and child-level factors and their relationship to child sleep problems. This chapter will present a general overview of etiologic models for children and youth. Then two separate manuscripts (Chapter 2 and 3) examining the relationship between neighbourhood- family- and child-level predictors on sleep outcomes with different samples (1) child (aged 4 to 11) and (2) youth (aged 12 to 17) are presented. The final chapter integrates findings across the studies.

Data for children and youth were examined separately for two reasons. First, the models of child and youth sleep problems have important differences. Second, in the 2014 Ontario Child Health Study (2014-OCHS) reporters provided information. For children, a person most knowledgeable and a person providing information provided reports for all variables. For youth, self-reported sleep outcomes and internalizing

problems were obtained, with the person most knowledgeable reporting on all other variables.

1.2. Etiologic Models and Sleep Problems

There are a number of conceptual models related to normal sleep and sleep problems, but models specific to children versus youth have important differences (e.g., Crowley et al., 2018; Sadeh & El-Sheikh, 2015; Tikotzky, 2017; Winters et al., 2007). Therefore, this chapter will discuss (1) a lifespan model of normal sleep, (2) models of sleep problems for (a) children and then (b) youth.

1.2.1. Lifespan Model

The two-process model applies across the life span and describes how circadian and homeostatic processes drive sleep (Borbély et al., 2016). The homeostatic process (i.e., sleep debt/drive) increases during wakefulness and decreases during sleep. The circadian process (i.e., daily cycle) regulates the timing of sleep and wakefulness through biological clocks and via the Suprachiasmatic Nucleus in particular (Borbély et al., 2016). This model emphasizes the neurological and biological processes of sleep, but recognizes biopsychosocial aspects (e.g., light, meal timing) also influence these processes. Together these processes interact to regulate the timing, quality and quantity of sleep (Spruyt, 2019).

1.2.2. Models of Sleep Problems in Children

The etiology of sleep problems in children involves complex transactions between circadian, neurodevelopmental, and contextual factors (Mindell et al., 2006). In childhood, the maturation of neural and circadian processes drives sleep consolidation (e.g., the emergence of bladder control facilitates sleep consolidation during the night). Neural and circadian development is influenced by environmental and behavioural variables (e.g., bedtime routine) making these variables important targets for intervention (Mindell et al., 2006).

Some models place more emphasis on psychosocial than biological factors in relation to sleep problems in children (Mindell et al., 2006; Sadeh & El-Sheikh, 2015). For example, Sadeh and El-Sheikh (2015) used an ecological systems perspective to

consider proximal and distal influences on infant sleep. This model incorporates the effects of child-parent relationships and parenting behaviours on infant sleep (Sadeh & El-Sheikh, 2015). Each of the models discussed recognizes the importance of biological, environmental, and behavioural factors in child sleep problems (Mindell et al., 2006; Sadeh & El-Sheikh, 2015). Most models focus primarily on the immediate factors related to child sleep problems, such as child and parenting factors. Models incorporating environmental factors are discussed below.

1.2.3. Models of Sleep Problems Specific To Youth

Similar to child models, models of sleep problems amongst adolescents also emphasize the importance of maturation. The maturing biological systems (e.g., circadian timing system, homeostatic process) underlying sleep initiation and maintenance undergo changes during adolescence (12-17 years old), making this time period sensitive to negative outcomes associated with sleep problems (Crowley et al., 2018). The perfect storm model focuses on the bidirectional relationship between biological (e.g., delayed sleep phase, hormones) and psychosocial factors (e.g., screen time, academic pressure) in adolescence (Crowley et al., 2018). Sleep problems in early childhood may also persist into adolescence and become chronic (Gregory & O'Connor, 2002). Therefore, investigating the factors that are related to sleep problems in this age group are important due to the potential chronic nature of sleep problems for some individuals.

1.3. Conceptual Framework Of The Current Study

This thesis extends the literature by focusing on environmental factors influencing children's sleep. Child, parent and family factors will be included in the model as control variables. First, a detailed description of the conceptual framework of the current study is discussed.

Bronfenbrenner's (1986) social-ecological model (Fig 1) captures the multiple factors at different levels that affect and interact to influence children's development. Elements/factors are organized by the context in which they occur; for example, the number of parents in the household occurs in the family-level context. These factors vary in the direct effect they have on a child's development, with some factors having more reciprocal and stronger direct effects. For example, parenting behaviour influences a

child and the temperament of that child in turn influences parenting behaviour (e.g., child-level factor; Simard et al., 2008). This model also stresses interactions across levels. For example, living in a neighbourhood characterized by high levels of violence may lead to higher levels of parenting stress which may, in turn, impair parents' abilities to use effective parenting strategies, thereby compromising a child's development.

Socio-Economic Status (SES) is another factor that may interact across levels of the model. For example, lower SES (e.g., income, education) may impair parents' ability to access enriching environments (e.g., diverse learning environments) for their children, thereby compromising a child's development. Interactions across levels may also occur at the neighbourhood-level, as neighbourhood amenities may help mitigate the effects of low SES. For example, neighbourhood libraries may promote access to enriching environments for low SES children. This model has been applied in other pediatric sleep studies and highlights the importance of factors beyond the family in relation to children's development (Reid et al., 2009; Williamson et al., 2019). The current studies will include a number of factors at each level of the social-ecological model.

In the following chapters research related to child, parent, and family factors will be briefly reviewed, followed by a detailed review of current knowledge on environmental factors.

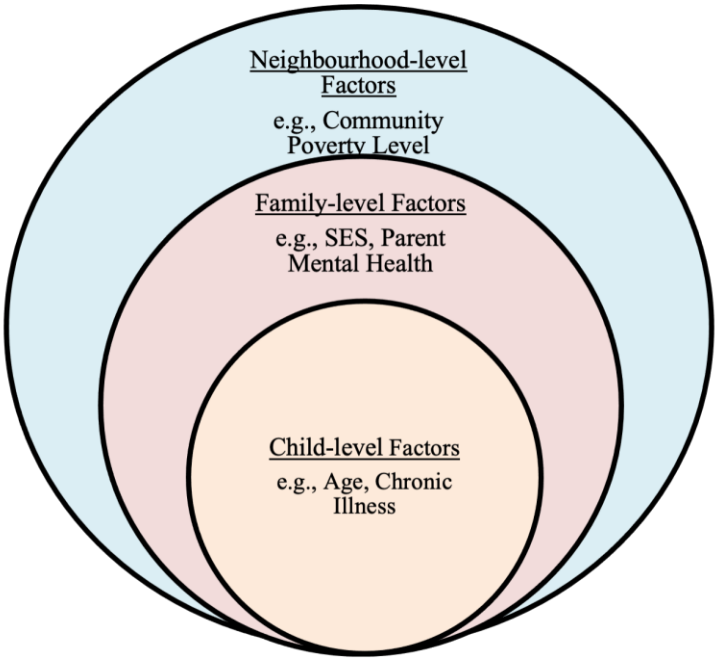


Figure 1. A visual representation of applying Bronfenbrenner's (1986) social-ecological model to factors related to child sleep problems in the current study.

Chapter 2

2. Neighborhood And Family Risk Factors And Child Sleep Problems

Sleep problems are related to a number of important outcomes such as behavioural problems, poor school performance, and poor physical and mental health (Armstrong et al., 2014; Coulombe et al., 2010). Importantly, approximately 40% of children (4-11) experience sleep problems (Owens, 2005). Research has focused on identifying the proximal child- and family-level factors related to child sleep outcomes. More recently, the relationship of neighbourhood-level factors (e.g., safety) has been investigated. However, gaps still remain. Specifically, no study to date has investigated the interactive relationship between neighbourhood- and family-level poverty on child sleep outcomes. This study will add to the literature by examining the relationship of neighbourhood-level factors to child sleep outcomes above and beyond previously identified important risk factors in a Canadian sample, using the social-ecological model as a framework.

Child- and family-level factors related to sleep problems in children have been summarized in a number of reviews (see Dahl & El-Sheikh, 2007; Newton et al., 2020). We briefly review the literature on the child- and family-levels that were included as control variables. The literature on neighbourhood variables is reviewed in more detail, as these were of primary interest in the current study. Of particular importance was the interactive association between family and neighbourhood socioeconomic characteristics, which have not been previously investigated in relation to child sleep problems.

2.1. Child-level Factors.

The prevalence of sleep problems tends to decrease with older ***age*** (Newton et al., 2020). Sleep problems such as bedtime resistance/insomnia and night waking decrease from childhood (aged 4) to adolescence (age 13 to 15; Gregory & O'Connor, 2002). Sleep duration also tends to decrease with age, as the prevalence of short sleep duration increases into adolescence (Felden et al., 2016; Galland et al., 2018). Children with ***chronic illnesses*** (e.g., diabetes, epilepsy, gastrointestinal disorders, kidney disease) are significantly more likely to report sleep problems than children without chronic illnesses (Sivertsen et al., 2009). Higher levels of mental health problems are associated with increased sleep problems in children (Dahl, 1996; Dahl & El-Sheikh, 2007; Quach et al.,

2018). Mental health problems can be conceptualized under the broad categories of ***internalizing*** problems (i.e., anxiety, depression) and ***externalizing*** problems (i.e., oppositional behaviour, conduct disorders, attention hyperactivity; Forbes et al., 2016; Lahey et al., 2017). The current study will control for the following child-level factors: age, sex, chronic illness, and internalizing and externalizing problems.

2.2. Family-level Factors.

Negative ***parenting behaviours*** (e.g., permissive/lax parenting) have been linked to increased sleep problems in children (Coto et al., 2018). Higher levels of parental mental health symptomology are also related to increased child sleep problems (Reid et al., 2009; Shang et al., 2006; Quach et al., 2012; Zuckerman et al., 1987). Finally, marital status (i.e., single-parent status) has also been identified as a risk factor and will be included in the current study (Newton et al., 2020).

The number of ***years lived in the neighbourhood*** will also be controlled for at the family-level (Boyle et al., 2019b). Other studies using the 2014-OCHS have found the number of years a family has lived in their neighbourhood to be a significant negative predictor in models at the family-level; that is, higher levels of mental health problems were related to shorter durations of time that a family lived in their neighbourhood (Boyle et al., 2019b). Another family-level factor relevant to children's sleep is ***socio-economic status*** (Newton et al., 2020). The current study focuses specifically on this factor at both the family- and neighborhood-level, and the interaction between family and neighborhood-level influences. As such, the literature on these two factors is reviewed below.

2.3. Neighbourhood-level Factors.

Child sleep problems are likely influenced by the complex interactions between the levels of influences in the social-ecological model (Meltzer et al., 2021). ***Neighbourhood-level factors*** refer to factors at the level of the neighbourhood or community where a child lives. Previous studies have found children's sleep problems to be related to less neighbourhood safety (e.g., resident perceptions of lower safety and higher incidences of crime), poor quality elements in the neighbourhood built environment (e.g., housing conditions and amenities present) and neighbourhood disadvantage (e.g., areas of high

unemployment; Bassett & Moore, 2014; Singh & Kenney, 2013; Troxel et al., 2018). ***Neighbourhood socioeconomic characteristics*** (e.g., the percentage of low-income individuals in a neighbourhood) and ***antisocial behaviour*** (e.g., the experience of theft from home) were examined in the current study, as previous research has suggested these factors are related to poorer sleep outcomes in children (Rubens et al., 2014; Troxel et al., 2018). However, no study to date has investigated these relationships with a sample of Canadian children. Investigating this issue with a Canadian sample is important due to the different social policies in place in Canada that may be operating at the family- and neighbourhood-level. For example, a study that compared the Canadian and United States healthcare systems found that Canadians were more likely to have met healthcare needs than Americans (LaPierre, 2012). These differences in health outcomes may extend to child sleep. Very few studies have investigated the effects of neighbourhood population (i.e., urban versus rural residency) which were also included in the current study.

2.3.1. Neighbourhood Characteristics.

Residency. The urban versus rural residency of the town a child lives in may have some relation to child sleep problems, but only two studies have examined this relationship (Spruyt et al., 2005; Yang et al., 2009). One study found the prevalence of sleep problems was significantly higher in children (aged 6 to 8; Yang et al., 2009) living in urban compared to rural locations. The second only found differences in the wake time and amount of light in the bedroom of urban and rural children; rural children woke up a few minutes later on weekends and weekdays and urban children were more likely to sleep in rooms with intrusive light than rural children (Spruyt et al., 2005). Due to these mixed findings, residency (i.e., rural, urban) was included as an exploratory variable.

Neighbourhood Antisocial Behaviour. Lower perceived safety and higher exposure to violence in a neighbourhood have been related to higher levels of sleep problems (Bailey et al., 2005; Spilsbury et al., 2016; Williamson et al., 2019). Previous studies have investigated neighbourhood social environments using diverse measures in which antisocial behaviours are often part of a composite score (see review by Mayne et al., 2021). For example, Singh and Kenny (2013) found 16% of children (aged 6-17) in the least socially favourable neighbourhoods (e.g., low neighbourhood safety, high litter, high dilapidated housing) had serious sleep problems, compared to 10% of children in

socially favourable neighbourhoods. Neighbourhood antisocial behaviour has been assessed in various ways. A common method has been through one self-reported question: for example, ‘Do you feel safe in your neighbourhood?’ (Pabayo et al., 2014). Other studies have used self-reported direct experience with violent crime (e.g., Bagley et al., 2016). To date, no studies have investigated experiences of assault, repeated verbal insult or disrespect, theft from the household property or household break-in on sleep problems. Previous studies have primarily assessed this in samples from the United States (Mayne et al., 2021b). The United States may have a higher violent crime rate, while Canada has higher rates of property crime (Gannon, 2001). Therefore, it is important to assess the relation of salient neighbourhood factors in the community children are living. Thus, the current study aimed to fill this gap by investigating the relationship between neighbourhood antisocial behaviour and child sleep outcomes.

2.4. Socio-Economic Characteristics

Socio-economic characteristics (SEC) are a multidimensional construct and have been quantified in different ways (e.g., Bassett & Moore, 2014; Kelly & El-Sheikh, 2016; Williamson et al., 2019). SEC has been conceptualized based on a family’s resources (e.g., income-to-needs ratio, family income), and status (e.g., the highest level of parental education; El-Sheikh et al., 2013). A second consideration is whether SEC is operationalized at the family-level (i.e., family-level socio-economic status; SES) or with neighbourhood characteristics (e.g., percentage of people living in poverty) as each level may have unique influences (El-Sheikh et al., 2013).

2.5. Family-level Socio-Economic Status.

Operationalizations of family-level SES in the sleep literature have included: (a) family income, (b) parental education level, (c) parental occupational status, and (d) composite scores of two or more of these factors (Blakemore et al., 2009). Different facets of SES may be related differentially to sleep (El-Sheikh et al., 2013). For example, an often-used metric is the income-to-needs ratio, which examines income in relation to a poverty threshold, which varies by household size (Kelly & El-Sheikh, 2016). In the current study, to better characterize family-SES, both income and parents’ educational attainment will be used.

Previous research has consistently linked lower family-level SES to poor sleep (e.g., Graham et al., 2020; Jarrin et al., 2014; Singh & Kenney, 2013; Troxel et al., 2018). Family economic deprivation (e.g., low-income) is associated with shorter duration and poorer quality of sleep among children (Bagley et al., 2018). Low income-to-needs ratio families have also been found to have children with higher rates of sleep problems, compared to higher SES families (Bagley et al., 2015).

Parent education level is a reliable stable indicator of SEC, as it is relatively fixed and stable across adulthood (Blakemore et al., 2009). El-Sheikh et al (2013) found lower maternal education was related to lower sleep efficacy in children.

2.6. Neighbourhood Socio-Economic Characteristics.

The findings on neighbourhood-level poverty and sleep problems are mixed (Biggs et al., 2013; Singh & Kenney, 2013; Uebergang et al., 2017; Williamson et al., 2019). For example, Bagley et al., (2018) examined neighbourhood poverty levels (i.e., percentage of households below the poverty line) in a socio-economically diverse sample of children. Higher neighbourhood-level poverty was associated with increased sleep problems (i.e., poorer sleep efficiency and fewer sleep minutes). In contrast, a recent review by Mayne and colleagues (2021) found more adverse neighbourhood SEC was associated with poorer sleep outcomes (i.e., shorter sleep duration, later sleep timing) in only 58% of studies. Thus, we expected neighbourhood poverty would predict significantly poorer sleep outcomes (i.e., more sleep problems and lower sleep durations).

2.7. The Interaction Between Neighbourhood And Family-Level SEC.

Most studies on neighbourhood-level poverty have compared families living in high vs low poverty neighbourhoods. Although this is a useful measure, using the level of poverty within a neighbourhood does not take into consideration the relative economic position of a family. The current study aimed to fill this gap. Bronfenbrenner's social-ecological (1986) model emphasizes that the interaction between levels of influence affects child development, but this has not been examined in relation to children's sleep. The interaction between neighbourhood-level SEC and family-level SES can be conceptualized by the relative economic position of a family. Relative economic position

compares a family's income to the income of residents of the same neighbourhood (Boyle et al., 2019b). For example, a low-income family would have relative deprivation if the families in the neighbourhood where they lived were more affluent. Boyle et al. (2019b) found an interactive relationship of family- and neighbourhood- income, such that low-income families had children (aged 4 to 17) with more mental health problems in less impoverished neighbourhoods compared with low-income families housed in neighbourhoods with higher concentrations of poverty. Child sleep problems are also expected to be associated with families' relative economic disadvantage based on social congruence theory (Albor et al., 2014). Social congruence theory would suggest individuals become stressed when comparing themselves to others, such as individuals in their neighbourhoods who are more affluent (Albor et al., 2014). Higher stress in the family overall, as well as parents and/or children, may impact children's ability to initiate and maintain sleep.

2.8. Objectives & Hypotheses

The primary objective of the current study was to examine the relative and interactive relationship between family-level SES and neighbourhood-level poverty in relation to child sleep problems and sleep duration, over and above the effects of variables known to be related to sleep problems (i.e., child age, sex, chronic illness, internalizing and externalizing problems, negative parenting behaviours) and controlling for neighbourhood size.

a. Hypothesis 1) Neighbourhood-level poverty will be related to child sleep problems and durations over and above the association of family-level SES (i.e., education, income), and child- and family-level control variables.
b. Hypothesis 2) We expect family- and neighbourhood-level poverty to interact such that children with a higher relative disparity between family-level and neighbourhood-level poverty (e.g., children from families with lower incomes relative to their neighbourhood) will have higher levels of sleep problems and lower sleep durations than children of lower relative disparity.

c. Hypothesis 3) We expect higher levels of neighbourhood antisocial behaviour will predict poorer sleep outcomes (i.e., more sleep problems and lower sleep durations) over and above the association of child- and family-level control variables.

2.9. Method

2.9.1 Datasets

Secondary analyses were conducted using two Canadian datasets: (a) the 2014 Ontario Child Health Study (2014-OCHS; Boyle et al., 2019; Statistics Canada, 2017); and (b) 2011 Canadian Census (Statistics Canada, 2012). Each dataset and variables are described below.

2014-OCHS Sample. The 2014 OCHS is a cross-sectional, province-wide probability sample of 6,537 households. Within each household, a target child was randomly selected (n = 6,537) and information was also collected on siblings (n = 4,265), for a total sample of 10,802 children aged 4 to 17 (Duncan et al., 2019). A subset of this sample (children aged 4-11) was used in the current study. This study used a sampling plan based on the Canada Child Tax Benefit File. In total, 12,871 households were approached, with a response rate of 50.8%. Detailed methods for the 2014-OCHS are reported elsewhere (Boyle et al, 2019a). Briefly, a complex 3-stage survey design was used. Sampling of households were clustered by residential areas, with stratification by urban vs rural areas and household income (both in terms of areas and family income at three levels: <20th, 20th to 80th, and >80th percentiles (Boyle et al, 2019a). The Person Most Knowledgeable (PMK; 87% mothers) provided ratings on the target child for all variables. For siblings of the target child sampled, Person Providing Knowledge (PPF; e.g., PMK's partner) completed ratings on the negative parenting behaviours scale specific for the sibling(s). Data were collected between October 2014 and September 2015.

2011 Canadian Census. Data from the 2011 Census was used to estimate the poverty level in each neighbourhood. The short Census questionnaire was distributed to 100% of households from May 2011 to July 2011. Survey response by households is

required by law. Information from each household used in this study included: family size (e.g., number of individuals in the household), and household income.

Defining Neighbourhoods. Neighbourhood-level variables were derived from the 2011 Census dissemination areas. A census dissemination area is a geographic unit of one or more adjacent blocks in a municipality (Statistics Canada, 2016). Census dissemination areas were used because they are the smallest geographical unit of analysis collected by Statistics Canada in each of the datasets and allowed us to capture participants' immediate neighbourhoods. Neighbourhood-level data was linked to each child in the 2014-OCHS using census dissemination area codes.

2.9.2. Outcome Variables

The four outcome variables fall into two groups: sleep problems and sleep duration. (A) For the sleep problem variables, the PMK was asked to report on sleep problems over the previous 6 months. Sleep problems were measured by three items: (a) Problems falling asleep (see Table 1 for response options and questions asked to PMK), (b) frequency of night wakings and (c) problems falling asleep again after a night waking. Two sleep problem variables were computed: (a) problems falling asleep (scores range from 1 to 4); (b) problems staying asleep, the sum of the two items related to night waking (scores range from 0 to 9). The problems staying asleep variable had an inter-item correlation of r = .61. (B) Two sleep duration variables were based on PMK-reported child bedtime and waketime on weekdays and weekends. Using the time the child fell asleep and woke up, sleep duration was calculated in hours and minutes for separately (a) weekdays and (b) weekends.

Sleep items on the 2014-OCHS were developed by experts in the field and were based on standardized measures. The validity of the specific sleep items used in the 2014-OCHS has not been examined. In general, parent-reported sleep outcomes are considered valid for screening sleep problems, but less consistent at measuring sleep outcomes than objective measures (i.e., actigraphy; Bauer & Blunden, 2008; Dayyat et al., 2011; Werner et al., 2008). Sleep duration assessed by parents via usual bed and wake times are less precise than actigraphy and sleep diary and may have about an hour margin of error (Werner et al., 2008).

Inter-correlations among the sleep outcomes (see Appendix A) showed moderate correlations (*r's* < .25), except for the correlation between weekend and weekday sleep duration which was large (*r* = .55).

2.9.3. Predictor Variables

The primary focus of this study was on neighbourhood-level factors. Thus, neighbourhood variables are presented first, followed by child and family variables conceptualized as control variables.

Neighbourhood-level Poverty. Consistent with previous literature, a single metric of neighbourhood-level poverty – the Low-Income Measure (LIM) - was computed (e.g., Bagley et al., 2018; Boyle et al., 2019b; Street et al., 2018; Troxel et al., 2017). The LIM is a low-income status relative to other incomes in the country (Statistics Canada, 2010; Veall, 2015). To calculate the LIM, first, each household's income in the Canadian population was adjusted for household size, as greater household size is related to a greater household need (Statistics Canada, 2015). Secondly, the LIM cut-off was the 25^{th} percentile of the adjusted income for all households in Canada (Statistics Canada, 2015). Third, the total number of households in each neighbourhood was calculated. Finally, the percentage of households that fall below the LIM was calculated for each neighbourhood (dissemination area) and used as a continuous measure of neighbourhood poverty. For example, the LIM in 2011 for a four-person household was $ 45,432 (Statistics Canada, n.d.).

Table 1. Sleep outcome measures, response options and coding schemes.

	Question asked to PMK	Response options	Coding scheme
Sleep Problem			
a) Problems falling asleep	'How long does it take this child to fall asleep at night'	*1* = [He/She] falls asleep very quickly (less than 5 minutes); *2* = A few minutes (5 to 10 minutes); *3* = A little while (11 to 30 minutes); *4* = A long time (more than 30 minutes);	No additional coding completed.
b) Problems staying asleep			
i) frequency of night wakings	'After this child has gone to sleep at night, how often does the child usually wake up during the night?'	*1* = Almost every night (5-7 times per week); *2* = Several times a week (1-4 times per week); *3* = Every now and then (2 or 3 times per month); *4* = He/She] almost never wakes up during the night; *5* = Never.	Reverse coded and added to problems falling asleep after a night waking.
ii) problems falling asleep after a night waking	'How long does it take this child to go back to sleep after he wakes up during the night?	*1* = [He/She] falls asleep very quickly (less than 5 minutes); *2* = A few minutes (5 to 10 minutes); *3* = A little while (11 to 30 minutes);	Individuals who answered never to frequency of night wakings were coded as 0. The sum of frequency of night wakings and problems falling

			4 = A long time (more than 30 minutes).	asleep after a night waking comprised problems staying asleep.
Sleep Duration				
i)	Weekdays	‘On weekdays … what time does he/she usually go to bed?’ ‘What time does _____ usually wake on school days?’	Respondents were asked to report the time in hours and minutes (e.g., 12:30 am). Sleep duration was calculated using bed and wake times.	Used as a continuous variable.
ii)	Weekends	‘When ___ doesn’t go to school, what time does she/he you usually go to bed?’ ‘What time does she/he usually wake on weekends?’	Respondents were asked to report the time in hours and minutes (e.g., 12:30 am). Sleep duration was calculated using bed and wake times.	Used as a continuous variable.

Note: Table 1 shows questions asked to PMK. In questions with blanks, questions included the child’s name.

Neighbourhood Antisocial Behaviour. PMKs responded to four questions about any household member's personal experience with (1) assault, (2) repeated verbal insult or disrespect, (3) theft from household property or (4) household break-in (*0 = No, 1= Yes*). Items were summed to form a cumulative score (Boyle et al., 2019b). Scores were then averaged for each neighbourhood (Boyle et al., 2019b). These questions were developed from the Kids, Families & Places Study (The Ontario Child Health Study Research Team, n.d.). This neighbourhood anti-social behaviour scale had solid test re-test reliability over two weeks (r = 0.72; Boyle et al., 2019b).

2.9.3.1 Socio-economic status & poverty

Family-level Socio-Economic Status: Education. The highest certificate, diploma or degree attained by parent or either parent (two-parent homes) from the 2014-OCHS was used for education attainment. Response options were based on the Canadian Census: *1= Less than high school diploma or its equivalent; 7 = University certificate, diploma, or a degree above the BA level*.

Family-level Poverty: Low-Income Measure (LIM). Self-reported total estimated before-tax household income in the past year was collected in the 2014-OCHS. Using the Census LIM, families were coded as (0) at/above the LIM or (1) below the LIM (Boyle et al., 2019b).

2.9.4. Neighbourhood-level Control Variables:

Residency. Population density and size of the census subdivision of the families' residence (based on postal codes) were obtained from the 2011 Census. Each neighbourhood was coded as a (1) large urban centre (population 100,000 or greater), (2) small-medium centre (population 1,000 to 99, 999), or (3) rural area (Statistics Canada, 2017b).

2.9.5. Family-level Control Variables:

Marital Status. PMK -marital status on the 2014-OCHS was based on the question: 'Does the child live in a single-parent or two-parent family.' Response options included: (0) two-parent family and (1) one-parent family (Boyle et al., 2019b).

Years Lived In Neighbourhood. PMK reports on the 2014-OCHS for the number of years they lived in their current neighbourhood was assessed with the

question: ‘How many years have you lived at this address?’ This was used as a continuous variable in years, as in other 2014-OCHS manuscripts (Boyle, et al., 2019a; Comeau et al., 2021).

Parent Mental Health Symptomology. PMK self-report on the 6-item K6 scale (Kessler et al., 2003) assessed the frequency of feelings in the last 30 days: (1) worthless, (2) nervous, (3) hopeless, (4) depressed, (5) restless or fidgety and (6) that everything was an effort. Response options ranged from 0 = *all of the time* to 4 = *none of the time*. Items were averaged to create scale scores for the PMK, where lower scores reflected higher mental health symptomology.

The K6 has been validated against structured diagnostic interviews and has well-established reliability and validity in community-based studies (α = .86; Kessler et al., 2003), including differentiating cases of serious mental illness from non-cases (Furukawa et al., 2003; Kessler et al., 2003). In the 2014-OCHS, internal consistency (α = 0.84) and two-week test-retest reliability were adequate (r = 0.79; Statistics Canada, 2017).

2.9.6. Child-level control variables:

Child Sex. Each child’s sex was collected based on demographic information provided by the PMK. Children were coded as either female (0) or male (1).

Chronic Illness. The PMK was asked, “Has a doctor or other health professional ever told you this child has any of the following conditions: food or digestive allergies, respiratory allergies, other allergies, bronchitis, diabetes, heart disease, epilepsy, cerebral palsy, kidney disease, asthma, eczema.” Children were coded as either having one or more chronic illnesses (1) or no chronic illness (0).

Internalizing Problems and Externalizing Problems. PMK completed the OCHS Emotional Behavioural Scales (OCHS- EBS) which assessed externalizing (25 items) and internalizing problems (27 items). Respondents rated the frequency of each item over the previous 6 months: 0 = *never or not true*, 1 = *sometimes or somewhat true*, and 2 = *often or very true*. Items were averaged to create scale scores. PMK reports for internalizing and externalizing problems exceeded 0.80 for internal consistency and test-retest reliabilities (Boyle et al., 2019b). Studies assessing the convergent and discriminant validity of the OCHS-EBS found it met criteria for internal and external convergent and discriminant validity when compared to the Mini International Neuropsychiatric

Interview for Children and Adolescents. Further information about the development and psychometric properties of the OCHS-EBS is available (Boyle et al., 2019c; Duncan et al., 2019).

Negative Parenting Behaviours. Negative parenting behaviours were assessed using a modified version of the Parent Behaviour Inventory subscale (Lovejoy et al., 1999). Parents reported how often they engaged in five parenting behaviours on a 5-point Likert scale (*1 = Never; 5 = Always*) in the last 6 months in relation to a specific child. The PMK reported on the target child. For other children in the family, a Person Providing Information (PPF) was asked to report on their negative parenting towards the child they were reporting on.

Items related to negative or hostile parenting behaviours including (a) threats (e.g., 'I threaten punishment more often than I use it,' 'Whether I keep or do not keep a rule depends on my mood'), (b) coercion (e.g., 'I nag him/her about little things'), (c) punishment ('I get angry and yell at him/her'), and (d) guilt ('I say mean things to make him/her feel bad'). A composite score was computed by averaging the responses of all 5 items. In the 2014 OCHS, this scale had adequate internal consistency ($\alpha = 0.77$) and two-week test-retest reliability ($r = 0.71$; Statistics Canada, 2017). As this measure was completed in relation to a specific child rather than parenting in general, negative parenting was conceptualized at the child-level.

2.10. Data Analyses

2.10.1. Missing Data Analyses.

Of a total of 6,374 individuals, 12.2% of participants were missing one or more of the variables in the current study. For the outcome variables, missing data analysis revealed missing data on sleep variables (1.7% of participants) was related to higher neighbourhood antisocial behaviour, higher neighbourhood levels of poverty, and older age (See Appendix B). Chi-squared analyses between missing sleep outcomes did not show significant relationships to missingness with the number of parents in the household, family-level poverty, residency, medical condition or child sex. Participants were excluded if they had one or more sleep outcomes missing (n = 110) from the final sample (n= 6, 264). Each predictor in the sample had a small proportion of missing data

(less than 5% overall). Full Information Maximum Likelihood (FIML) with robust standard errors was used to estimate missing values for all predictors.

2.10.2. Multi-Level Regression Models.

MPlus (version 8.5) was used to estimate parameters for multilevel regression models in the current study. Sampling weights based on the probability of being selected and participating in the study created by Statistics Canada were applied to children, between households and between neighbourhoods.

Multi-level regression models were used in the current study, as children were nested within families (level 2) and neighbourhoods (level 3) in the sampling design. In line with the study objectives, variables were centered in two ways in the models to aid in interpretation and reduce multicollinearity (Enders & Tofighi, 2007). 1) Child age, internalizing problems, externalizing problems, negative parenting behaviours, PMK depression, parent education and years lived in the neighbourhood were all grand-mean centered; that is, the sample mean was subtracted from each participant's score. 2) family-level poverty was group-mean centered; that is, the mean poverty status for each neighbourhood was subtracted from each participant's poverty score. We aimed to compare individuals' poverty status to the poverty in their neighbourhood via the cross-level interaction, which included group-mean centered family poverty. Investigating the relationship of lower level variables (i.e., family) by cluster (i.e., neighbourhood) is best achieved using group-mean centering in an interaction term, as within and between cluster relationships are parsed apart with group-mean centering (Enders & Tofighi, 2007). Thus, group-mean centered coefficients can be thought of as representing an individual's poverty status in relation to their neighbourhood. We included other child- and family-level variables in the models as covariates. The aim of their inclusion is to control for their relationships to sleep outcomes, not to investigate the relationship of these covariates by neighbourhood cluster. Grand-mean centering is suited for investigating the relationship between lower level (i.e., child, family) variables without considering higher-level cluster variables (i.e., family cluster, neighbourhood cluster); grand-mean centering does not parse apart within and between cluster relationships (Enders & Tofighi, 2007). Thus, grand-mean centered coefficients can be thought of as

representing individuals' scores in relation to all participants in the sample (Curran & Bauer, 2021).

A five-step model-building approach was used to assess the relationship of the predictors on each of the four sleep outcome variables above and beyond the associations of the control variables in the current study (Peugh, 2010). Four models were run – one for each of the four sleep outcome variables. (1) An intercept-only model was used to examine the variation in child sleep outcomes explained by family and neighbourhood clusters. (2) Child-level control variables (i.e., age, sex, chronic illness, negative parenting, internalizing and externalizing problems) and then (3) family-level SES and control predictors (i.e., parent mental health symptomology, marital status, years lived in the neighbourhood, education level) were added. (4) The random effects for family-level SES income were tested, to examine if family-level income varied by neighbourhood. (5) Neighbourhood-level SES and neighbourhood-level control variables (i.e., residency, antisocial behaviour, poverty level) were then added to the model. (6) Finally, the cross-level interaction between family-level poverty and neighbourhood-level poverty was included to test the relationship between relative economic disparity on sleep outcomes, as per hypothesis one.

Family-level poverty was included at step 4 as a random effect. Random effects allow for the coefficients and slopes of variables to vary between neighbourhoods (Finch & Bolin, 2017). Significant findings would mean there is significant variation in slopes of family poverty between neighbourhoods, suggesting a significant cross-level interaction may exist (Finch & Bolin, 2017). The Intra-class correlation (ICC) was calculated for the final model of each outcome to show how much variance in the model was explained at the neighbourhood-level, family-level and the families nested in neighbourhoods level (Lorah, 2018). Significant interactions were plotted at ±1 standard deviation of neighbourhood poverty and family-level poverty to investigate the nature of the interaction.

2.11. Results

The sample was 50% male with a mean age of 7.50 (SD = 2.27). Households included in this study were primarily two-parent households (82.6%), educated (55.9% had a

bachelor's degree or above), and 81.0% of the sample had a family income above the LIM cut-off (i.e., family poverty). The families included were primarily white (60.6%) and 61.7% of families had an income of 75,000 and above.

Table 2 presents the prevalence of sleep problem items, demographics and descriptives for outcomes and predictors. Children slept an average of 9.85 hours on weekdays and 9.92 hours on weekends. Just over 1 in 10 children (11.1%) took more than 30 minutes to fall asleep, which is considered a clinically significant delay in sleep onset (Sateia et al., 2017).

Table 2. Weighted prevalences and descriptives of child sleep outcomes, predictors and demographics.

Variable	M (SD)	Range or %
Sleep Outcomes		
Weekday sleep duration	9.85 (0.97)	5-11
Less than 8 hours		10.44%
9.0-9.9 hours		26.97%
10.0-10.9 hours		44.37%
11.0-11.9 hours		18.27%
Weekend sleep duration	9.92 (1.10)	5-13
Less than 8 hours		11.31%
9.0-9.9 hours		24.36%
10.0-10.9 hours		40.0%
11.0+ hours		23.49%
Problems staying asleep	2.01 (1.96)	0-8
Problems falling asleep	2.21 (0.99)	1-4
I fall asleep very quickly; less than 5 minutes		29.2%
A few minutes; 5-10 minutes		31.3%
A little while; 11-30 minutes		28.4%
A long time; more than 30 minutes		11.1%
Predictors		

Child-level		
Age	7.50 (2.27)	4-11
Sex		0-1
Male		50%
Female		50%
Internalizing problems	0.20 (0.22)	0-2
Externalizing problems	0.24 (0.24)	0-2
Chronic Illness		0-1
With chronic illness		23.6%
No chronic illness		76.4%
Negative parenting	1.07 (0.65)	1-5
Family-level		
Marital Status		0-1
Single parent family		17.4%
Two-parent family		82.6%
Parent mental health symptomology	0.52 (0.59)	0-4
Years lived in the neighbourhood	8.74 (7.01)	0-57
Family poverty		0-1
No family poverty		81.0%
Family poverty		19.0%
Highest parent education		
Less than a Bachelor degree[1]		44.1%
A Bachelor's degree		32.3%
Above a Bachelor's degree		23.6%
Neighbourhood-level		
Residency	2.66 (0.67)	0-3
Rural		10.6%
Small/medium urban		13.4%
Large urban		76.0%
Neighbourhood poverty	13.46 (12.54)	0-73.4
Neighbourhood antisocial behaviour	0.49 (0.56)	0-4

Demographics	
Ethnicity	
White	60.6%
South Asian	9.1%
Other[2]	27.2%
Income	
<24,999	13.0%
25,000-74,999	25.2%
75,000-1,999,999	46.9%
>2,000,000	14.8%

Note: N= 6, 264; Each child was weighted based on the probability of being selected for the study. M (SD) = Mean (Standard deviation).

[1] = due to vetting guidelines at the research data centre (RDC) the following groups had to be aggregated: Grade 8 or lower; grade 9-10; grade 11-12 not completed; secondary school completed; trade certificate/diploma; college, CEGEP or other non-university certificates/diplomas; university certificate below the bachelor's level. [2] = due to vetting guidelines at the RDC the following groups had to be aggregated: Chinese, Black, Filipino, Latin American, Arab, Southeast Asian, West Asian, Korean, Japanese, Other.

2.11.1 Predicting Child Sleep Outcomes

Tables 3 and 4 present results from the final step of the regression analyses. Full results for each step of the model for each outcome are presented in Appendix C. The significance for each block/step in the model is summarized, followed by a description of the significant predictors from the final step of the model.

Problems Falling Asleep. For problems falling asleep inclusion of all the child-level predictors were all significant (see Table 3). None of the family-level predictors were significant above and beyond the child-level factors. Neighbourhood-level factors – residency and antisocial behaviour – added significantly to the model. In the final step, the cross-level interaction (family x neighbourhood) was non-significant. The ICCs showed that 9.0% of the variance in problems falling asleep was accounted for at the neighbourhood-level, 4.0% at the family-level and 13.7% at the level of families nested within neighbourhoods.

In the final model, older age (ß= 0.03), being female (ß = -0.13), higher levels of internalizing problems (ß = 0.74) and the presence of one or more chronic illnesses (ß = 0.10) significantly predicted higher levels of problems falling asleep at the child-level. At the neighbourhood-level, smaller neighbourhood populations (ß = -0.05) and neighbourhoods with higher levels of antisocial behaviour (ß = 0.13) predicted higher levels of problems falling asleep.

Problems Staying Asleep. For problems staying asleep, only sex was non-significant when adding in the child-level predictors (see Table 3). For the family-level predictors, entered as fixed effects, only the number of years lived in the neighbourhood was statistically significant. The final steps (neighbourhood-level and cross-level interactions) were non-significant. The ICCs of the final model showed 12.93% of the variance in problems staying asleep was accounted for at the neighbourhood-level, 8.62% at the family-level and 21.55% at the level of families nested within neighbourhoods.

Younger age (ß = -0.13), higher levels of internalizing problems (ß = 1.18), higher levels of externalizing problems (ß = 0.47), the presence of one or more chronic illnesses (ß = 0.20) and higher levels of negative parenting (ß = 0.13) all predicted more problems staying asleep.

Weekday Sleep Duration. For weekday sleep duration, the model building showed only two significant child-level variables (see Table 3). When adding the family-level variables, only parent education level was a significant predictor. However, after adding family-level poverty as a random effect, parent education was no longer statistically significant. Adding the neighbourhood-level variables revealed two significant predictors. The cross-level interaction was non-significant in the final step of the model. The ICCs of the final model showed 17.57% of the variance in weekday sleep duration was accounted for at the neighbourhood-level, 29.73% at the family-level, and 47.30% at the level of families nested within neighbourhoods.

Older children (ß = -0.16) and higher levels of internalizing problems (ß = -0.46) predicted shorter weekday sleep duration at the child level. At the neighbourhood-level, neighbourhoods with larger populations (ß = -0.08) and higher neighbourhood-levels of poverty (ß = -0.01) predicted significantly lower sleep durations on weekdays.

Weekend Sleep Duration. The weekend sleep duration model building showed a number of significant child-level predictors and when adding family-level predictors, parent depression significantly predicted weekend sleep duration (see Table 4). When family-level poverty was added as a random effect, it was non-significant; all of the neighbourhood-level predictors added in the next step were also not statistically significant. Finally, the cross-level interaction was significant in the final step of the model. The ICCs of the final model showed 5.02% of the variance in weekend sleep duration was accounted for at the neighbourhood-level, 9.40% at the family-level and 14.42% at the level of families nested within neighbourhoods.

Older children (ß = -0.12), being female (ß = -0.21) and having higher levels of internalizing problems (ß = -0.30) significantly predicted shorter weekend sleep duration. The interaction between family poverty and neighbourhood poverty was significant (See Figure 1 for graph). The interaction showed the longest weekend sleep durations were in children with family poverty in low neighbourhood poverty neighbourhoods and children without family poverty in high neighbourhood poverty neighbourhoods (10 hours). Conversely, the shortest sleep durations were in children without family poverty and low neighbourhood poverty and children with family poverty with high neighbourhood poverty (9.7 hours).

Table 3. Fixed effects and random effects for multilevel regression models of child sleep problems.

	Unconditional				Model 6			
	Problems falling asleep		Problems staying asleep		Problems falling asleep		Problems staying asleep	
	ß	(SE)	ß	(SE)	ß	(SE)	ß	(SE)
Fixed effects								
Intercept	2.22***	(0.02)	2.04***	(0.03)	2.36***	(0.06)	2.16***	(0.15)
Level 1: Children								
Age (in years)					0.02***	(0.01)	-0.13***	(0.01)
Sex (1 = male)					-0.13***	(0.03)	0.04	(0.06)
Internalizing Problems[a]					0.74***	(0.12)	1.18***	(0.22)
Externalizing Problems[b]					0.19	(0.11)	0.47*	(0.21)
Chronic Illness (1 = one or more chronic illness)					0.10**	(0.04)	0.20**	(0.07)
Negative Parenting[c]					0.05	(0.03)	0.13**	(0.05)
Level 2: Families								
PMK Marital status (1 = single parent family)					-0.06	(0.05)	0.07	(0.09)
PMK Mental Health Symptomology[d]					0.02	(0.03)	0.06	(0.07)
Years Lived in Neighbourhood[e]					-0.00	(0.00)	0.01	(0.01)
Education Level[f]					-0.00	(0.01)	0.00	(0.02)
Level 3: Neighbourhoods								
Residency[g]					-0.05*	(0.02)	-0.05	(0.05)
Neighbourhood-level Poverty[h]					-0.00	(0.00)	-0.00	(0.00)

Neighbourhood Antisocial Behaviour[i]					0.13***	(0.03)	0.00	(0.07)
Cross-Level Interaction								
Family-level Income Measure x Neighbourhood-level Poverty					0.00	(0.00)	0.01	(0.01)
Random effects								
Level 1: Children	0.82***	(0.03)	2.90***	(0.12)	0.75***	(0.03)	2.73***	(0.11)
Level 2: Families	0.05*	(0.03)	0.46***	(0.11)	0.04	(0.03)	0.30**	(0.10)
Level 3: Neighbourhoods	0.12***	(0.01)	0.53***	(0.06)	0.08***	(0.01)	0.45***	(0.06)
Family-level Income Measure Random Effect					0.07	(0.09)	-0.10	(0.17)
Model summary								
Deviance statistic	17353.19		25800.17		15116.02		22717.02	
Number of estimated parameters	4		4		21		21	

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. LIM= Low-income Measure. Some Betas were rounded to .00, but ranged from 0.001 to 0.004.

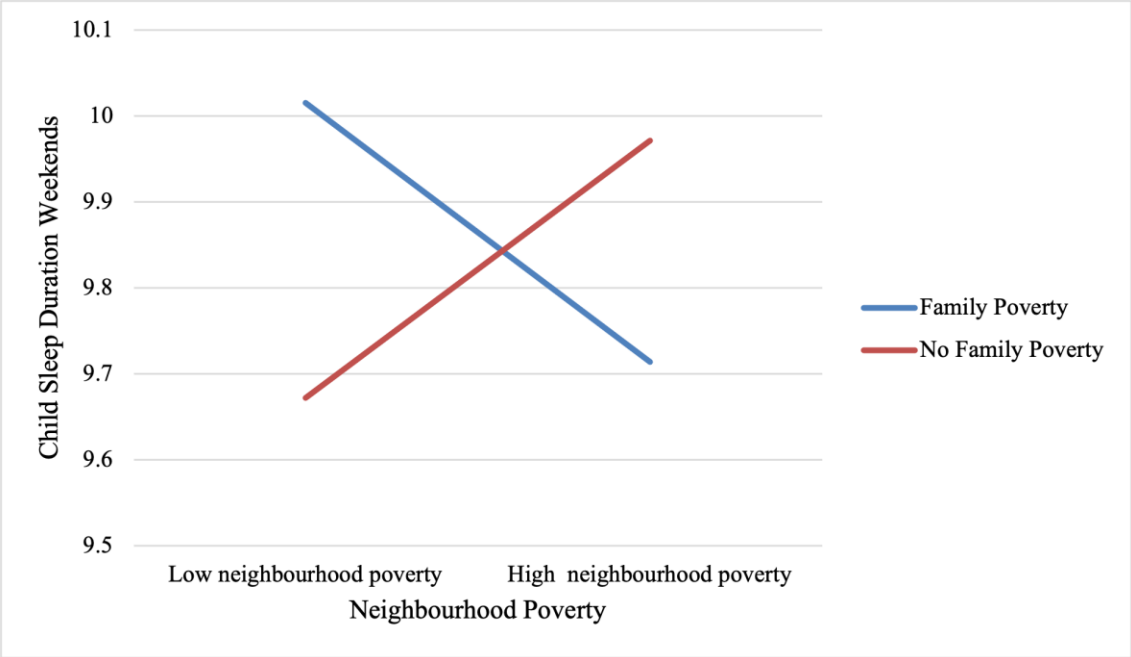
Table 4. Fixed effects and random effects for multilevel models of child sleep durations.

	Unconditional				Model 6			
	Weekday sleep duration		Weekend sleep duration		Weekday sleep duration		Weekend sleep duration	
	ß	(SE)	ß	(SE)	ß	(SE)	ß	(SE)
Fixed effects								
Intercept	9.84**	(0.02)	9.92***	(0.02)	10.13***	(0.06)	9.99***	(0.08)
Level 1: Children								
Age (in years)					-0.16***	(0.01)	-0.12***	(0.01)
Sex (1 = male)					-0.03	(0.03)	-0.21***	(0.03)
Internalizing Problems[a]					-0.46***	(0.10)	-0.30**	(0.12)
Externalizing Problems[b]					-0.15	(0.10)	-0.16	(0.12)
Chronic Illness (1 = one or more chronic illness)					-0.02	(0.03)	-0.02	(0.04)
Negative Parenting[c]					0.02	(0.03)	-0.05	(0.03)
Level 2: Families								
PMK Marital status (1 = single parent family)					-0.03	(0.04)	0.05	(0.06)
PMK Mental Health Symptomology[d]					-0.03	(0.03)	-0.07	(0.04)
Years Lived in Neighbourhood[e]					0.00	(0.00)	0.00	(0.00)
Education Level[f]					0.02	(0.01)	0.02	(0.01)
Level 3: Neighbourhoods								
Residency[g]					-0.08***	(0.02)	0.01	(0.03)
Neighbourhood-level Poverty[h]					-0.01**	(0.00)	0.00	(0.00)
Neighbourhood Antisocial Behaviour[i]					0.03	(0.04)	0.02	(0.04)

Cross-Level Interaction								
Family-level Poverty x Neighbourhood-level Poverty					0.01	(0.01)	0.01*	(0.00)
Random effects								
Level 1: Children	0.48***	(0.03)	0.71***	(0.04)	0.39***	(0.03)	2.73***	(0.11)
Level 2: Families	0.34***	(0.03)	0.38***	(0.04)	0.22***	(0.03)	0.30**	(0.10)
Level 3: Neighbourhoods	0.14***	(0.02)	0.16***	(0.02)	0.13***	(0.02)	0.16***	(0.02)
Family-level Income Measure Random Effect					-0.06	(0.09)	-0.18	(0.10)
Model summary								
Deviance statistic	16690.02		18452.12		13689.82		15957.15	
Number of estimated parameters	4		4		21		21	

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. Some Betas were rounded to .00, but ranged from 0.001 to 0.004.

Figure 2. The interaction between neighbourhood-level and family poverty



Note. Family poverty was having an income below the low-income measure (LIM) cut-off. No family poverty was having an income above the LIM. Neighbourhood poverty was measured by the percent of households in the neighbourhood with an income below the LIM cut-off. Low neighbourhood poverty is one standard deviation (SD) below and high neighbourhood poverty is one SD above the mean.

2.12. Discussion

There are four novel findings in the current study. Firstly, residency (i.e., neighbourhood population) was differentially related to sleep outcomes. Children living in large, urban areas (population > 10,000) had shorter weekday sleep duration; while living in smaller communities was related to problems falling asleep. Second, higher levels of neighbourhood antisocial behaviour predicted more problems falling asleep. Third, relative economic position (the interaction between family-level poverty and neighbourhood poverty) significantly predicted weekend sleep duration. Finally, age and internalizing problems emerged as important child-level predictors for all the sleep outcomes. A discussion of the main variables of interest will be discussed in the following order (1) neighbourhood antisocial behaviour, (2) socio-economic status, (3)

the interaction between neighbourhood and family poverty, (4) child-level predictors. Then we discuss the limitations and future research directions in this area.

2.12.1. Neighbourhood Anti-Social Behaviour

Higher neighbourhood antisocial behaviour significantly predicted problems falling asleep in children. These findings are similar to other studies on the relationship between a range of neighbourhood-level social environmental exposures and children's sleep (Bailey et al., 2005; Wamser-Nanney & Chesher, 2018). For example, Bailey and colleagues (2005) found experiences of child-reported community violence (e.g., seeing someone be stabbed, adults hit each other) were related to higher reports of difficulty sleeping in children. Interestingly, a review by Mayne et al., (2021) found only half of the studies that have assessed safety concerns at the neighbourhood-level have found significant associations with sleep duration; whereas, 84% of studies assessing sleep problems have found significant associations with measures of neighbourhood safety. Therefore, our findings on problems falling asleep are consistent with the literature. Neighbourhood antisocial violence likely affects children's ability to fall asleep via stress, which results in heightened arousal preventing sleep onset (Dahl, 1996). Further, community violent crime has been shown to result in later bedtimes the night following a crime and disrupted cortisol patterns the next morning in children (Heissel et al., 2018). Children living in neighbourhoods with higher levels of antisocial behaviour may experience more stress about their safety than children living in neighbourhoods with low antisocial behaviour. For example, one of the antisocial behaviours in the measure was household break-ins. Children who know their house has been broken into in the past may be anxious or fearful about their house being broken into in the future preventing sleep onset.

Additionally, our non-significant sleep duration findings were consistent with half of the literature. The review by Mayne et al., (2021) suggested a number of reasons for the heterogeneity in sleep duration outcome findings. (1) Differences in how sleep duration is measured. Studies assessing sleep duration have used actigraphy or questionnaires, while all studies assessing sleep problems have used questionnaires. Specifically, parent-reported sleep problems and sleep duration by actigraphy were more likely to find significant associations with neighbourhood safety than child self-reported

sleep durations. (2) The operationalization of neighbourhood safety varied widely across studies. Some articles have investigated perceived safety, others have included a wide range of items in the construct (e.g., witnessing a violent crime, perceptions of overall safety). Different characteristics of neighbourhood safety may relate differently to sleep outcomes and the timing of exposure to those events may be of particular importance (Spilsbury et al., 2014). However, the authors did not discuss how these variations would have resulted in discrepancies in the literature.

The current study assessed the average antisocial behaviour for each neighbourhood. It may be more important to assess subjective neighbourhood variables directly experienced by children as opposed to objective measures. For example, children may not have been exposed to neighbourhood antisocial behaviour occurring in their neighbourhood if it was not something directly experienced by their family.

2.12.2. The Contribution Of Socio-Economic Status To Children's Sleep

Neighbourhood-level poverty significantly predicted shorter weekday sleep duration. Interestingly, about half of studies that included a measure of neighbourhood SEC found shorter sleep durations were related to more adverse characteristics (Mayne et al., 2021a). This may be due to differences in the operationalizations of neighbourhood SEC. Some studies have used indexes of neighbourhood SEC which combined multiple aspects of the neighbourhood, while others have used single measures (Mayne et al., 2021a). For example, Williamson et al., (2019), used an index made up of neighbourhood facilities, livability (e.g., safety, cleanliness), neighbourhood income, unemployment and education. Conversely, El-Sheik et al., (2013) used Title 1 status (i.e., child's school designated as having a high number of low-income families). A review article identified that single measures were more likely to find significant relationships between sleep durations and timing, but did not speculate as to why this difference exists. The current study used a single indicator and found one significant relationship out of the four sleep outcomes.

Studies that have found neighbourhood SEC to be related to poor sleep duration have suggested a number of reasons for this effect, but few have investigated mechanisms (Mayne et al., 2021a). Importantly, no study to date has investigated if these mechanisms mediate the relationship between neighbourhood-level SEC and child sleep outcomes.

Suggested mechanisms have been proposed at multiple levels including parent attitudes on fixed bedtime schedules, family/household conditions such as overcrowded living situations, and neighbourhood levels of noise and access to amenities (Biggs et al., 2013; McLaughlin Crabtree et al., 2005; Sheehan et al., 2018). In the current study higher neighbourhood-level poverty predicted lower weekday sleep duration. Children in neighbourhoods with less neighbourhood poverty may be more likely to live in suburbs making a personal vehicle more essential for travel and driving their children to school easier. Conversely, individuals of low SES living in areas of high neighbourhood poverty may be more likely to use school buses to get to school. As a result, children in high poverty neighbourhoods may have to wake earlier on weekdays to access school busing programs to get to school, than children living in more affluent neighbourhoods. Given the variation in significant findings in the literature, it is imperative that research focus on the mechanisms driving these relationships at the neighbourhood-level, such as if the method of transportation to school is mediating the relationship between neighbourhood SEC and sleep outcomes.

2.12.3. Relative Economic Position And Child Sleep Outcomes

The interaction between neighbourhood and family poverty was significant for weekend sleep duration, above and beyond the other predictors in the model. The longest sleep durations (10 hours) were among children in (1) poor families living in low poverty neighbourhoods (i.e., relatively deprived), and (2) non-poor families living in high poverty neighbourhoods. The shortest sleep durations (9.7 hours) were among children from non-poor families living in low poverty neighbourhoods and poor families living in high poverty neighbourhoods. It is important to note that these differences show children with family poverty in low poverty neighbourhoods slept almost 20 minutes longer than their relatively advantaged counterparts. Importantly, a 30-minute difference is considered clinically meaningful, so the difference between the groups was approaching clinical significance (Meltzer et al., 2020; Sateia et al., 2017). We did not predict that children living in low poverty neighbourhoods with no family-level poverty would have the shortest weekend sleep duration. However, a few studies that have assessed neighbourhood SEC in adolescents have found higher SEC is related to lower sleep durations (Pabayo et al., 2014; Street et al., 2018; Troxel et al., 2017). This could be due

to higher SEC children being enrolled in more extracurricular activities on weekends. Higher SEC children may also have higher access to electronics before bed which contributed to difficulties falling asleep (Street et al., 2018). Children living in low poverty neighbourhoods with no family-level poverty may have more disposable income than children living in households with no family poverty in high poverty neighbourhoods; thus, enabling their access to electronics before bed more than their no family poverty counterparts living in high poverty neighbourhoods.

As hypothesized, children with family poverty and in high neighbourhood poverty did have shorter sleep durations. Thus, there is a compounding association of household and neighbourhood poverty that might prevent children from sleeping longer on weekends. For example at the family-level, children with family poverty may have to wake earlier on weekends to accommodate parent's work schedules. Whereas, high neighbourhood-level poverty may result in more neighbourhood noise delaying bedtimes. As mentioned above, the mechanisms behind the relationship between neighbourhood poverty and child sleep problems are ill-defined and should be explored in future studies. Examining social jetlag as an outcome would also be useful. Social jet lag refers to the difference in weekday and weekend sleep duration (Roenneberg et al., 2019).

2.12.4. Child-level Predictors

Older age predicted fewer sleep problems and lower sleep durations. This finding is consistent with the developmental trajectory of sleep problems and the recommendations of sleep durations by age (Newton et al., 2020; Paruthi et al., 2016). Across all sleep outcomes internalizing problems significantly predicted poor outcomes: more sleep problems and lower sleep durations. Previous research has shown internalizing problems and sleep outcomes are concurrently related in children (Becker et al., 2017). Specifically, children with internalizing problems may have difficulty regulating fear and arousal preventing sleep onset (Conway et al., 2017). The inclusion of mental health problems as a child-level predictor is novel in the literature on neighbourhood factors and child sleep outcomes (Bagley et al., 2015; Biggs et al., 2013; Graham et al., 2020; Singh & Kenney, 2013; Williamson et al., 2019). Mental health problems tend to be related to lower SES (Letourneau et al., 2013); therefore; there may be interactions between child internalizing and neighbourhood-level factors that could be examined in future studies.

2.12.5. Implications for Child Sleep Health.

The results of the current study show that neighbourhood-level factors may have important implications for child sleep health above and beyond child- and family-level risk factors. Specifically, children in families with poverty living in poorer neighbourhoods appear to be at risk for shorter sleep durations on weekends. Interestingly, the children with family poverty living in low poverty neighbourhoods had the longest sleep duration on weekends. This may mean that these children are benefitting from the amenities of the higher SEC neighbourhoods they live. Municipal housing policies in Ontario such as Housing Now in Toronto and the housing stability action plan in London aim to promote socio-economic mixing in neighbourhoods (City of London, 2019; City of Toronto, n.d.). The results of this study may suggest policymakers should continue to invest in policies that focus on socio-economic mixing, as it may have benefits for child sleep health. However, this recommendation differs from Boyle et al., (2019), who found children with family poverty living in low poverty neighbourhoods had higher levels of mental health problems (Boyle, Georgiades, Duncan, Wang, et al., 2019). Future research should investigate the potential protective factors (e.g., consistent bedtime schedules) that may promote longer sleep in children with family poverty living in more affluent neighbourhoods. Further, the results of this study showed a compounding association of weekend sleep duration for children with family poverty living in high poverty neighbourhoods. Therefore, investments into high poverty neighbourhoods should be a policy priority, especially for children with household poverty. The interaction between family poverty and neighbourhood poverty shows the complex interactions that occur between levels of the social-ecological model.

2.12.6. Limitations

There are also some important limitations to consider in the current study. First, the cross-sectional design of the study did not allow us to look at causal relationships between the variables. Future research should aim to use longitudinal studies, natural experiments or quasi-experimental designs which could strengthen causal inferences between neighbourhood factors and sleep outcomes. Second, the low-income measure used does not account for the cost of living in the city the family lived. This may be an important consideration given the cost of living between rural and urban places may

differ. We used the LIM to facilitate comparisons to other studies (Boyle, Georgiades, Duncan, Wang, et al., 2019; Comeau et al., 2021). Not accounting for rural-urban differences in the cost of living might attenuate the observed associations. Third, the dissemination areas used in the current study are geographically larger for rural areas than urban areas. Dissemination areas in Canada are the same in population size (i.e., range from 400 to 700 people); as a result, less densely populated areas are geographically larger. This may mean children living in rural areas are less likely to experience the effects of their "neighbourhood". Fourth, missing data analyses showed differences between individuals missing a sleep outcome and individuals with complete data on major predictor variables. This may play a role in the results of this study as high neighbourhood poverty was significantly related to missing a sleep outcome variable. As noted, 1.4% of the total sample was missing one or more sleep outcomes. Therefore, the sample may be missing out on meaningful sleep outcome data for neighbourhoods with higher concentrations of poverty, which may have impacted our results. Fifth, this study used other-reports for all data in the study, so shared method variance may be playing a role in findings. Sixth, the residency variable used was a categorical variable; therefore, more sensitive measures of population density should be investigated in the future. Finally, sleep duration in the current study was assessed by asking parents to report the usual bed and wake times of their children. This measure may have a margin of error of an hour (Werner et al., 2008). Therefore, the results of this study should be replicated with actigraphy data or sleep diary data.

Summary and Future Research: The results of the current study suggest neighbourhood factors may have unique relationships to specific sleep outcomes (e.g., neighbourhood antisocial behaviour and problems falling asleep) and future research should investigate the mechanisms between neighbourhood-level factors and sleep outcomes. Additionally, the findings from this study show that internalizing problems emerged as an important predictor in all sleep outcomes and should be included in future studies investigating neighbourhood factors and child sleep outcomes.

Appendix A: Outcome variable correlations

A.1. Correlations between child sleep outcome variables.

	Problems Falling Asleep	Problems Staying Asleep	Weekday Sleep Duration
Problems Staying Asleep	.19**		
Weekday Sleep Duration	-.21**	-.08**	
Weekend Sleep Duration	-.11**	-.11**	.55**

Note: N= 6,264; ** = p <.01.

Appendix B: T-tests of comparing children with and without missing sleep outcome variables

Table 5. T-tests for missing sleep outcome data

Variable	t	Cohen's d
Predictors		
Child-level		
Age	.33*	.23
Sex[1]		
Internalizing problems	-.42	-.05
Externalizing problems	-1.77	-.20
Chronic Illness[1]		
Negative parenting	-.77	-.09
Family-level		
Marital Status[1]		
Parent mental health symptomology	-.12	-.02
Years lived in the neighbourhood	-.17	-.02
Family poverty[1]		
Highest parent education	-.99	-.18
Neighbourhood-level		
Residency[1]		
Neighbourhood poverty	2.28*	.34
Neighbourhood antisocial behaviour	3.59***	.55

Note: Groups coded as 0= data for all four outcomes (n= 6,264); 1 = one or more missing sleep outcomes (n=110); M = mean. SE= Standard Error; ***= p<.001, **= p<.01, *= p<.05; This table is weighted by the child's probability of being selected for the study. All t-tests compared the missingness of a sleep outcome to each variable. Due to vetting guidelines degrees of freedom and mean differences could not be released. [1] = Chi-squared analyses for nominal data revealed no significant differences based on groups with and without missing data, but due to vetting requirements did not meet the minimum cell count to be released.

Appendix C: Full tables of all steps of multi-level models for child sleep outcomes

Table C.1

Full fixed and random effects for multilevel models of child problems staying asleep outcome.

	Unconditional	Child-level Predictors: Fixed	Family-level predictors: Fixed	Family-level Predictors and Family-level income random effect	Neighbourhood-level predictors fixed	Interaction between Neighbourhood poverty and Family income
	ß (SE)	ß (SE)	ß (SE)	ß (SE)	ß (SE)	ß (SE)
Fixed effects						
Intercept	2.04*** (0.03)	2.04*** (0.03)	2.03*** (0.04)	2.04*** (0.04)	2.04*** (0.04)	2.16*** (0.15)
Level 1: Children						
Age (in years)		-0.13*** (0.01)	-0.13*** (0.01)	-0.13*** (0.01)	-0.13*** (0.01)	-0.13*** (0.01)
Sex (1 = male)		0.04 (0.06)	0.04 (0.060)	0.04 (0.06)	0.04 (0.06)	0.04 (0.06)
Internalizing Problems[a]		1.19*** (0.22)	1.20*** (0.23)	1.20*** (0.22)	1.20*** (0.22)	1.18*** (0.22)
Externalizing Problems[b]		0.46* (0.21)	0.41* (0.22)	0.46* (0.21)	0.46* (0.21)	0.47* (0.21)
Chronic Illness (1 = one or more chronic illness)		0.25** (0.07)	0.20** (0.07)	0.21** (0.070)	0.21** (0.07)	0.20** (0.07)
Negative Parenting[c]		0.16** (0.05)	0.15** (0.05)	0.14** (0.052)	0.14** (0.05)	0.13** (0.05)
Level 2: Families						
PMK Marital status (1 = single parent family)			0.05 (0.09)	0.04 (0.09)	0.04 (0.09)	0.06 (0.09)

PMK Mental Health Symptomology[d]			0.07 (0.07)	0.06 (0.07)	0.06 (0.06)	0.06 (0.07)
Years Lived in Neighbourhood[e]			0.01* (0.00)	0.01* (0.00)	0.01* (0.00)	0.01 (0.00)
Education Level[f]			0.00 (0.02)	0.00 (0.02)	0.00 (0.02)	0.00 (0.02)
Family-level poverty (1 = below LIM)			0.01 (0.11)			
Level 3: Neighbourhoods						
Residency[g]						-0.10 (0.17)
Neighbourhood-level Poverty[h]						-0.05 (0.05)
Neighbourhood Antisocial Behaviour[i]						-0.00 (0.00)
Cross-Level Interaction						
Family-level poverty measure x neighbourhood-level poverty						0.01 (0.01)
Random effects						
Level 1: Children	2.90*** (0.12)	2.76*** (0.11)	2.73*** (0.11)	2.73*** (0.11)	2.73*** (0.11)	2.73*** (0.11)
Level 2: Families	0.46*** (0.11)	0.39*** (0.10)	0.40*** (0.11)	0.30** (0.10)	0.30** (0.10)	0.30** (0.10)
Level 3: Neighbourhoods	0.53*** (0.06)	0.48*** (0.06)	0.46*** (0.06)	0.44*** (0.06)	0.44*** (0.06)	0.45*** (0.06)
Family-level income measure random effect				0.04 (0.11)	0.04 (0.11)	-0.10 (0.17)
Model summary						
Deviance statistic	25800.17	24907.05	22957.02	22920.93	22717.95	22717.02

Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.

Table C.2

Full fixed and random effects for multilevel models of child problems falling asleep outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	2.22***(0.02)	2.22***(0.02)	2.24*** (0.02)	2.32*** (0.06)	2.36*** (0.06)	2.36*** (0.06)
Level 1: Children						
Age (in years)		0.03*** (0.01)	0.03*** (0.01)	0.02*** (0.01)	0.02*** (0.01)	0.02*** (0.01)
Sex (1 = male)		-0.13*** (0.03)	-0.12*** (0.03)	-0.13*** (0.03)	-0.13*** (0.03)	-0.13*** (0.03)
Internalizing Problems[a]		0.71*** (0.11)	0.72*** (0.12)	-0.74*** (0.12)	0.74*** (0.12)	0.74*** (0.12)
Externalizing Problems[b]		0.25** (0.10)	0.23* (0.11)	0.19 (0.12)	0.19 (0.11)	0.19 (0.11)
Chronic Illness (1 = one or more chronic illness)		0.12** (0.04)	0.10** (0.04)	0.10** (0.04)	0.10** (0.04)	0.10** (0.04)
Negative Parenting[c]		0.07** (0.02)	0.05* (0.03)	0.05* (0.03)	0.05 (0.03)	0.05 (0.03)
Level 2: Families						

PMK Marital status (1 = single parent family)			-0.08 (0.05)	-0.06 (0.05)	-0.06 (0.05)	-0.06 (0.05)
PMK Mental Health Symptomology[d]			0.04 (0.03)	0.03 (0.03)	0.03 (0.03)	0.02 (0.03)
Years Lived in Neighbourhood[e]			-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Education Level[f]			0.01 (0.01)	-0.00 (0.01)	-0.00 (0.00)	-0.00 (0.01)
Family-level poverty (1 = below LIM)			0.10 (0.06)			
Level 3: Neighbourhoods						
Residency[g]				-0.05* (0.02)	-0.05* (0.02)	-0.05* (0.02)
Neighbourhood-level Poverty[h]				-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.001
Neighbourhood Antisocial Behaviour[i]				0.13*** (0.03)	0.13*** (0.03)	0.13*** (0.03)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.00 (0.00)
Random effects						
Level 1: Children	0.82*** (0.03)	0.76*** (0.03)	0.77*** (0.03)	0.75*** (0.03)	0.75*** (0.03)	0.75*** (0.03)
Level 2: Families	0.05* (0.03)	0.06* (0.03)	0.05 (0.3)	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)
Level 3: Neighbourhoods	0.12*** (0.01)	0.09*** (0.01)	0.09*** (0.01)	0.09*** (0.01)	0.08*** (0.01)	0.08*** (0.01)
Family-level poverty random effect				0.09 (0.06)	0.08 (0.06)	0.07 (0.09)

Model summary						
Deviance statistic	17353.19	16689.17	13925.12	13851.32	15116.05	15116.02
Number of estimated parameters	4	10	15	19	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. LIM= Low-income Measure.

Table C.3

Full fixed and random effects for multilevel models of child weekday sleep duration outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	9.84** (0.02)	9.85*** (0.02)	9.89*** (0.02)	9.88*** (0.02)	10.13*** (0.06)	10.13*** (0.06)
Level 1: Children						
Age (in years)		-0.16***(0.01)	-0.16*** (0.01)	-0.16*** (0.01)	-0.16*** (0.01)	-0.16*** (0.01)
Sex (1 = male)		-0.03 (0.02)	-0.04 (0.03)	-0.034 (0.03)	-0.03 (0.03)	-0.03 (0.03)
Internalizing Problems[a]		-0.46*** (0.10)	-0.45*** (0.10)	-0.44*** (0.10)	-0.46*** (0.10)	-0.46*** (0.10)
Externalizing Problems[b]		-0.19 (0.10)	-0.18 (0.10)	-0.17 (0.10)	-0.14 (0.10)	-0.15 (0.10)
Chronic Illness (1 = one or more chronic illness)		-0.03 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)	-0.02 (0.03)
Negative Parenting[c]		0.03 (0.03)	0.02 (0.03)	0.03 (0.03)	0.02 (0.03)	0.02 (0.03)
Level 2: Families						

PMK Marital status (1 = single parent family)			-0.04 (0.05)	-0.05 (0.04)	-0.03 (0.04)	-0.03 (0.04)
PMK Mental Health Symptomology[d]			-0.03 (0.03)	-0.03 (0.03)	-0.03 (0.03)	-0.03 (0.03)
Years Lived in Neighbourhood[e]			0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Education Level[f]			0.02* (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
Family-level poverty (1 = below LIM)			0.030 (0.059)			
Level 3: Neighbourhoods						
Residency[g]					-0.08*** (0.02)	-0.08*** (0.02)
Neighbourhood-level Poverty[h]					-0.01** (0.00)	-0.01** (0.00)
Neighbourhood Antisocial Behaviour[i]					0.03 (0.04)	0.03 (0.04)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.01 (0.00)
Random effects						
Level 1: Children	0.48*** (0.03)	0.38*** (0.02)	0.39*** (0.03)	0.39*** (0.03)	0.39*** (0.03)	0.39*** (0.03)
Level 2: Families	0.34*** (0.03)	0.28*** (0.03)	0.26*** (0.03)	0.22*** (0.03)	0.22*** (0.03)	0.22*** (0.03)
Level 3: Neighbourhoods	0.14*** (0.02)	0.14*** (0.02)	0.15*** (0.02)	0.14*** (0.02)	0.13*** (0.02)	0.13*** (0.02)
Family-level poverty random effect				0.04 (0.05)	0.03 (0.05)	-0.06 (0.09)
Model summary						

	16690.02	15197.46	13925.12	13851.32	13691.81	13689.82
Deviance statistic						
Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. LIM= Low-income Measure.

Table C.4

Full fixed and random effects for multilevel models of child weekend sleep duration outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	9.92*** (0.02)	9.92*** (0.02)	10.03*** (0.03)	10.02*** (0.03)	9.99*** (0.08)	9.99*** (0.08)
Level 1: Children						
Age (in years)		-0.11*** (0.01)	-0.12*** (0.01)	-0.12*** (0.01)	-0.12*** (0.01)	-0.12*** (0.01)
Sex (1 = male)		-0.22*** (0.03)	-0.22*** (0.03)	-0.21*** (0.03)	-0.21*** (0.03)	-0.21*** (0.03)
Internalizing Problems[a]		-0.38*** (0.11)	-0.33** (0.12)	-0.30** (0.11)	-0.30** (0.11)	-0.30** (0.12)
Externalizing Problems[b]		-0.13 (0.11)	-0.14 (0.12)	-0.15 (0.11)	-0.15 (0.11)	-0.16 (0.12)
Chronic Illness (1 = one or more chronic illness)		-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)	-0.02 (0.04)
Negative Parenting[c]		-0.05 (0.03)	-0.05 (0.03)	-0.04 (0.03)	-0.05 (0.03)	-0.05 (0.03)
Level 2: Families						

PMK Marital status (1 = single parent family)			0.06 (0.05)	0.06 (0.06)	0.05 (0.06)	0.05 (0.06)
PMK Mental Health Symptomology[d]			-0.07* (0.04)	-0.06 (0.03)	-0.06 (0.04)	-0.07 (0.04)
Years Lived in Neighbourhood[e]			0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Education Level[f]			0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
Family-level poverty (1 = below LIM)			0.04 (0.07)			-0.18 (0.10)
Level 3: Neighbourhoods						
Residency[g]					0.01 (0.03)	0.01 (0.03)
Neighbourhood-level Poverty[h]					0.00 (0.00)	0.00 (0.00)
Neighbourhood Antisocial Behaviour[i]					0.02 (0.04)	0.02 (0.04)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.01* (0.01)
Random effects						
Level 1: Children	0.71*** (0.04)	0.63*** (0.04)	0.63*** (0.04)	0.63*** (0.04)	0.63*** (0.04)	0.63*** (0.04)
Level 2: Families	0.38*** (0.04)	0.036*** (0.04)	0.34*** (0.04)	0.28*** (0.04)	0.29*** (0.04)	0.29*** (0.04)
Level 3: Neighbourhoods	0.16*** (0.02)	0.15*** (0.02)	0.17*** (0.02)	0.16*** (0.02)	0.16*** (0.02)	0.16*** (0.02)
Family-level poverty random effect				0.02 (0.07)	0.02 (0.07)	-0.18 (0.10)

Model summary						
Deviance statistic	18452.12	17505.39	16159.62	16095.01	15963.52	15957.15
Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.LIM= Low-income Measure.

Chapter 3

3. Neighbourhood and Family Risk Factors and Adolescent Sleep Problems

Recent reviews have summarized important adolescent- and family-level risk factors to adolescent sleep (see Bartel et al., 2015; Becker et al., 2017). But much less is known about the impact of neighbourhood-level factors. The literature on the adolescent- and family-level factors is briefly reviewed. Then a detailed discussion of neighbourhood factors (the primary focus of this article) related to adolescents' sleep is presented. Specifically, the current study investigates the relationship of relative economic position in predicting sleep outcomes in adolescents, using the social-ecological model as a framework.

3.1. Adolescent-level Factors

The developmental trajectory of sleep problems across childhood into adolescence suggests the prevalence of sleep problems and sleep duration decrease from age four to mid-adolescence (age 13 to 15; Gregory & O'Connor, 2002; Simola et al., 2012). An estimated 9-12% of adolescents report having sleep problems every night (Ipsiroglu et al., 2002; Johnson et al., 2006). Sleep duration decreases from late childhood across adolescence from approximately 10.5 hours at age nine years to 9 hours at age 17 years (Leger et al., 2012; Olds et al., 2010). Thus, age is a critical factor to include when examining predictors of sleep problems. Adolescents with ***chronic illnesses*** (e.g., diabetes, epilepsy, gastrointestinal disorders, kidney disease) have also been found to be at increased risk for problems falling asleep and night wakings (Hysing et al., 2009).

Another established adolescent-level factor is mental health problems (Gregory & O'Connor, 2002; see review by Meltzer, 2017). Mental health problems can be conceptualized as ***internalizing*** problems (i.e., anxiety, depression) and ***externalizing*** (i.e., oppositional behaviour, conduct disorders, attention hyperactivity) problems (Forbes et al., 2016; Lahey et al., 2017). Higher levels of mental health problems are associated with increased sleep problems in adolescence (Dahl & Lewin, 2002; Shimizu et al., 2021). This relationship is bi-directional and complex, as the underlying mechanisms that drive sleep may also factor into the development of psychopathology during adolescence (Harvey et al., 2011; Meltzer, 2017; Wang et al., 2016). The current study will control for

the following child-level factors: age, sex, chronic illness, and internalizing and externalizing problems.

3.2. Family-level Factors.

At the family-level, ***negative parenting behaviours*** (e.g., permissive/lax parenting) have been related to increased sleep problems in adolescents (Brand et al., 2009). Parent mental health has also been shown to be an important risk factor to child sleep problems; higher parent mental health symptomology is related to increased child sleep problems (Reid et al., 2009; Shang et al., 2006; Quach et al., 2012; Zuckerman et al., 1987). However, parent mental health has not been extensively investigated in relation to adolescent sleep problems. Therefore, parent mental health will be included as a control variable to explore its relationship to adolescent sleep problems.

Other studies using the 2014-OCHS have found the ***number of years a family has lived in their neighbourhood*** to be a significant negative predictor of psychopathology in models at the family-level; therefore, we have included it in the current study as well (Boyle et al., 2019b). Finally, single-parent family status (i.e., ***marital status***) has been shown to be related to poorer sleep efficiency and shorter weekend sleep durations in adolescents and was included as a control variable in this study (Troxel et al., 2014).

Another relevant family-level factor is ***socio-economic status.*** The current study investigated this factor at the family- and neighborhood-level, and the interaction between the two. This literature is reviewed below.

3.3. Neighbourhood Characteristics.

Residency. Only two studies have examined the relationship of urban versus rural residency to adolescent sleep problems (Patte et al., 2017; Yang et al., 2009). One study found significantly higher daytime sleepiness in urban vs rural pre-adolescents (aged 9 to 12; Yang et al., 2009). The other study found adolescents from rural and small urban areas had longer sleep durations than large urban areas (aged 14 to 18; Patte et al., 2017). Due to the limited literature on this variable, residency (i.e., rural, urban) was included as an exploratory variable.

Neighbourhood Antisocial Behaviour. The social makeup of a neighbourhood has also been identified as a relevant factor to adolescent sleep outcomes (Rubens et al.,

2019, 2020; Singh & Kenney, 2013). A recent review of neighbourhood-level factors and their relationship to child and youth sleep showed neighbourhood social environment (i.e., qualities related to relations between community members) was associated with adverse self-reported sleep outcomes in adolescents (Mayne et al., 2021). For example, Singh and Kenny (2013) found 10% of children and adolescents (aged 6-17) in socially favourable neighbourhoods (e.g., high neighbourhood safety, low litter, few dilapidated houses) had serious sleep problems (i.e., less than five days of adequate sleep), in comparison to 16% of children in the least socially favourable neighbourhoods. The literature has thus far used diverse measures to examine neighbourhood social environment including social favourability of the neighbourhood (i.e., high neighbourhood safety, low litter, few dilapidated houses), neighbourhood facilities (e.g., number of homes needing repairs), and safety. However, none to date have investigated experiences of antisocial behaviours such as assault, repeated verbal insult or disrespect, theft from the household property or household break-in with an adolescent sample. Therefore, this study aimed to fill that gap. We expected that neighbourhoods with high antisocial behaviour to be related to negative sleep outcomes (i.e., more sleep problems and lower sleep durations) due to higher levels of stress or hypervigilance from antisocial behaviour.

3.4. Socio-Economic Characteristics

Socio-economic characteristics (SEC) refers to a multi-dimensional construct that can be measured at varying levels of the social-ecological model (e.g., Bassett & Moore, 2014; Kelly & El-Sheikh, 2016; Williamson et al., 2019). Previous research has measured SECs in a multitude of ways at the family-level (e.g., parent education level, household income) and the neighbourhood-level (e.g., number of people in the neighbourhood living in poverty, number of people using public assistance). Both aspects were considered.

3.4.1 Family-level Socio-Economic Characteristic.

Operationalizations of family-level Socio-Economic characteristics (SEC) in the sleep literature has included the assessment of different facets of family-level socioeconomic status (SES): (a) family income, (b) parental education level, (c) parental occupational status, and (d) composite scores of two or more of these factors (Blakemore et al., 2009).

A review by Felden et al., (2015) identified family-level measures of low SES to be related to poor subjective sleep outcomes for adolescents in a number of studies. Specifically, low-income was associated with shorter duration and poorer quality of sleep in a sample of children and adolescents (Bagley et al., 2018). Low SES (i.e., low income-to-needs ratio) families appear to have adolescents with higher rates of sleep problems (Bagley et al., 2015).

Parent education level may be a reliable indicator of SES because it is relatively fixed and stable across adulthood, unlike employment status (Blakemore et al., 2009). Troxel et al., (2017) used maternal education as a measure of family-level SES and found lower education related to significantly more sleep problems (i.e., trouble sleeping and shorter total sleep time) in youth. The current study will examine two family-level SES metrics: parental education level and poverty status (i.e., household above or below low-income cut-off).

3.4.2 Neighbourhood Socio-Economic Characteristics

There have been few studies on neighbourhood-level poverty and sleep problems (Bagley et al., 2018; Marco et al., 2012; Singh & Kenney, 2013; Street et al., 2018; Troxel et al., 2017). For example, Bagley et al., (2018) found higher neighbourhood-level poverty (i.e., percentage of households below the poverty line) was associated with increased sleep problems (i.e., poorer sleep efficiency, shorter sleep duration) in both children and adolescents. Most studies on neighbourhood-level poverty have compared families living in high vs low poverty neighbourhoods. However, none to date have investigated the relative economic position of a family.

3.4.3 The Interaction Between Neighbourhood and Family-level Sec

Bronfenbrenner's social-ecological (1986) model emphasizes that the interaction between levels of influence affect child development. Therefore, the interaction between neighbourhood-level SEC and family-level SES (i.e., relative economic position) may be related to adolescent sleep outcomes. Relative economic position compares a family's income to the income of residents of the same neighbourhood (Boyle et al., 2019b). For example, a low-income family would have relative deprivation if the families in the neighbourhood they lived in were more affluent. Relative economic position has been

examined in relation to child and youth mental health problems, but not sleep. Boyle et al. (2019b) found an interactive association between family- and neighbourhood- income, such that low-income families had children (aged 4 to 17) with fewer mental health problems in less impoverished neighbourhoods compared with low-income families housed in neighbourhoods with higher concentrations of poverty. Adolescent sleep problems are also expected to be associated with families' relative economic disadvantage, based on social congruence theory. Social congruence theory would suggest individuals become stressed when comparing themselves to others, such as individuals in their neighbourhoods who are more affluent (Albor et al., 2014). Higher stress in the family overall, parents and/or children may impact children's ability to initiate and maintain sleep.

3.5 Objectives & Hypotheses

The primary objective of the current study was to examine the relative and interactive association of family-level SEC and neighbourhood-level poverty in relation to adolescent sleep problems and sleep duration, over and above the variables known to be related to sleep problems (i.e., age, sex, chronic illness, internalizing and externalizing problems, negative parenting behaviours) and controlling for neighbourhood size.

a. Hypothesis 1) Neighbourhood-level poverty will be related to adolescent sleep problems over and above family-level SEC (i.e., education, income) and control variables.
b. Hypothesis 2) We expect family- and neighbourhood-level poverty to interact such that adolescents with the higher relative disparity between family-level and neighbourhood-level poverty (e.g., adolescents from families with lower incomes relative to their neighbourhood) will have higher levels of sleep problems than adolescents with lower relative disparity.
c. Hypothesis 3) We expect neighbourhood antisocial behaviour to predict poorer sleep outcomes (i.e., more sleep problems, lower sleep durations) in adolescents above and beyond child-, family-level control variables.

3.6 Method

3.6.1. Datasets

Secondary analyses were conducted using two Canadian datasets: (a) the 2014 Ontario Child Health Study (2014-OCHS; Statistics Canada, 2017a); and (b) the 2011 Canadian Census (Statistics Canada, 2012). Each dataset and the variables used are described below.

2014-OCHS Sample. The 2014 OCHS is a cross-sectional, province-wide probability sample of 6,537 households and 10,802 children aged 4 to 17. Within each household, a target child was randomly selected (n = 6,537) and information was also collected on siblings (n = 4,265) (Duncan et al., 2019). The 2014 OCHS used a sampling plan based on the Canada Child Tax Benefit File. In total, 12,871 households were approached, with a response rate of 50.8%. Detailed methods for the 2014 OCHS are reported elsewhere (Boyle et al, 2019a). Briefly, a complex 3-stage survey design was used. Sampling of households were clustered by residential areas, with stratification by urban vs rural areas and household income (both in terms of areas and family income at 3 levels: <20th, 20th to 80th, and >80th percentiles; Boyle et al, 2019a).

This project used a subset of adolescents (aged 12 to 17). Adolescent self-report were available for sleep outcomes, and internalizing and externalizing problems; for all other variables, the Person Most Knowledgeable (PMK; 87% mothers) ratings were used. For the negative parenting scale a Person Providing Knowledge (PPF; e.g., PMK's partner) reported on their negative parenting behaviours used for siblings included in the study. Data were collected between October 2014 and September 2015.

2011 Canadian Census. Data from the 2011 Census was used to compute the poverty levels in each neighbourhood. The short Census questionnaire was distributed to 100% of Canadian households from May 2011 to July 2011. Survey response by households is required by law. Neighbourhood-level characteristics were then linked to child data using census dissemination area codes.

Defining Neighbourhoods. Neighbourhoods were derived from the Census dissemination areas. Census dissemination areas are a geographic unit of one or more adjacent blocks in a municipality (Statistics Canada, 2016). Census dissemination areas are designated by 400 to 700 people; therefore, rural dissemination areas can be

geographically larger than urban dissemination areas. Census dissemination areas were used because they are the smallest geographical unit of analysis collected in each of the datasets and allowed us to capture participants' immediate neighbourhood.

3.7 Outcome Variables

Four outcome variables were used, which fall into two groups: two sleep problem variables and two sleep duration variables. (1) For the sleep problem variables, youth were asked to report on sleep problems over the previous 6 months. Sleep problems were measured by three items: (a) problems falling asleep (scores ranged 1-4; see Table 5 for response options and questions asked to youth), (b) problems staying asleep, the sum of (i) frequency of night wakings and (ii) problems falling asleep after a night waking (scores ranged from 0-8). The problems staying asleep variable had an inter-item correlation of r = .49. (2) For the sleep duration outcomes, youth reported bedtimes and waketimes for weekdays and weekends were used to calculate sleep durations. The number of hours and minutes of average weekday and weekend sleep duration was entered as separate outcome variables for each model.

Sleep items on the 2014-OCHS were developed by experts in the field and were based on standardized measures. The validity of the specific sleep items used in the 2014-OCHS has not been examined. Similar measures of self-reported weekend and weekday sleep duration have been shown to be significantly correlated with sleep diaries and actigraphy (Wolfson et al., 2003). Correlations between all sleep outcome variables are presented in Appendix D.

Table 6. Summary of sleep outcome measures and response options

	Question asked to youth	Response options	Coding scheme
Sleep Problem			
a) Problems falling asleep	'How long does it take you to fall asleep at night'	*1* = I fall asleep very quickly (less than 5 minutes); *2* = A few minutes (5 to 10 minutes); *3* = A little while (11 to 30 minutes); *4* = A long time (more than 30 minutes);	No additional coding was completed.
b) Problems staying asleep			
i) frequency of night wakings	'After you have gone to sleep at night, how often do you usually wake up during the night?'	*1* = Almost every night (5-7 times per week); *2* = Several times a week (1-4 times per week); *3* = Every now and then (2 or 3 times per month); *4* = I almost never wake up during the night; *5* = Never.	Reverse coded and added to problems falling asleep after a night waking.
ii) problems falling asleep after a night waking	'How long does it take you to go back to sleep after you wake up during the night?	*1* = I fall asleep very quickly (less than 5 minutes); *2* = A few minutes (5 to 10 minutes); *3* = A little while (11 to 30 minutes); *4* = A long time (more than 30 minutes).	Individuals who answered never to frequency of night wakings were coded as 0. The sum of frequency of night wakings and problems falling asleep after a night waking comprised problems staying asleep.
Sleep Duration			
iii) Weekdays	'On weekdays … what time do you usually go to bed?'	Respondents were asked to report the time in hours and minutes (e.g., 12:30 am). Sleep	Used as a continuous variable.

		‘What time do you usually wake on school days?’	duration in hours was calculated using bed and wake times.	
iv)	Weekends	‘When you don’t go to school, what time do you usually go to bed?’ ‘What time do you usually wake on weekends?’	Respondents were asked to report the time in hours and minutes (e.g., 12:30 am). Sleep duration in hours was calculated using bed and wake times.	Used as a continuous variable.

3.8 Predictor Variables

As the primary focus of this study was on neighbourhood-level factors, these variables are presented first, followed by other adolescent and family variables, which are conceptualized as control variables.

3.8.1. Neighbourhood Variables

Neighbourhood-level Poverty. Consistent with previous literature, a single metric of neighbourhood-level poverty was computed (i.e., Bagley et al., 2018; Boyle et al., 2019b; Street et al., 2018; Troxel et al., 2017). The Low-Income Measure (LIM) is a low-income status relative to other incomes in the country; thus, it is a measure of relative poverty (Statistics Canada, 2010; Veall, 2015). The 2011 Canadian Census Low-Income Measure (LIM) was used. To calculate the LIM, first, each household's income in the Canadian population was adjusted for household size, as greater household size is related to a greater household need (Statistics Canada, 2015). Secondly, the LIM cut-off was the 25^{th} percentile of the adjusted income for all households in Canada (Statistics Canada, 2015). Third, the number of households in each neighbourhood was computed. Fourth, the percentage of households that fall below the LIM was calculated for each neighbourhood; this percentage was used as the measure of neighbourhood poverty. For example, the LIM in 2011 for a four-person household was $ 45,432 (Statistics Canada, n.d.).

Neighbourhood Antisocial Behaviour. PMK self-report on four questions about any household member's personal experience with (1) assault, (2) repeated verbal insult or disrespect, (3) theft from household property or (4) household break-in (*0 = No, 1= Yes*). Items were summed to form a cumulative score then averaged for each neighbourhood (Boyle et al., 2019b). These questions were developed from the Kids, Families & Places Study (The Ontario Child Health Study Research Team, n.d.). The neighbourhood anti-social behaviour scale was shown to have solid test re-test reliability over two weeks (r = 0.72; Boyle et al., 2019b).

3.8.2. Family Variables

Family-level Socio-Economic Status: Education. The highest certificate, diploma or degree attained by parent or either parent (two-parent homes) from the 2014 OCHS was used for education. The score ranged from *1= Less than a high school diploma or its equivalent, to 7 = University certificate, diploma, or a degree above the BA level*.

Family-level Poverty. Self-reported total estimated household income in the past year before taxes was collected in the 2014 OCHS. Using the Census low-income measure (LIM) and family income, families were coded as (0) at or above the LIM; or (1) below the LIM (Boyle et al., 2019b).

3.8.3. Control Variables

Control variable measures, descriptions, coding schemes, reliability and test-retest reliabilities are presented in Table 6.

Table 7. Summary of control variable measures

	Description	Item Responses	Computation of Scores
Child-level			
Internalizing problems	Youth reports from the OCHS Emotional Behavioural Scales (OCHS- EBS) were used. Youth scales exceeded 0.80 for internal consistency and test-retest reliabilities (Boyle et al., 2019a). Youth and PMK internalizing scores were moderately correlated (r = .41).	0, *never or not true;* 1, *sometimes or somewhat true;* 2, *often or very true*.	The 27 items were averaged to create scale scores, where higher scores indicate more problems.
Externalizing problems	PMK reports from the OCHS- EBS were used (De Los Reyes et al., 2015). Internal consistency and test-retest reliabilities exceed 0.80 for PMK reports (Boyle et al., 2019a). Youth and PMK externalizing scores were moderately correlated (r = .41).	0, *never or not true;* 1, *sometimes or somewhat true*; 2, *often or very true*.	The 27 items were averaged to create scale scores, where higher scores indicate more problems.
Negative parenting behaviours	Parents were asked to report how often they engaged in parenting behaviours on a 5-point Likert scale in the last 6 months. Items relate to: negative or hostile parenting behaviours including: (a) threats, (b) coercion, (c) punishment and (d) guilt (α = 0.77 and test-retest r = 0.71).	1, *never;* 2, *rarely;* 3, *sometimes;* 4, *often;* 5, *always.*	Scores were computed by averaging the responses of all 5 items, where higher scores indicate higher use of negative parenting behaviours.
Chronic illness	The PMK was asked, "Has a doctor or other health professional ever told you this child has any of the following conditions: food or digestive allergies, respiratory allergies, other allergies, bronchitis, diabetes, heart disease, epilepsy, cerebral palsy, kidney disease, asthma, eczema."	0, *no;* 1, *yes.*	Coded as either having one or more chronic conditions (1) or no chronic illness (0).
Child Sex	Each child's sex was collected based on demographic information provided by the PMK.		Coded as (0) female or (0) male.
Family-level			
Marital Status	PMK self-reported marital status was used.	1, *married*; 2, *living common-law*;	Coded as: 1 = single parent; 0 = non-single parents

		3, *widowed*; 4, *separated*; 5, *divorced*; 6, *single*.	
Parent mental health symptomology	PMK self-reports on the 6-item K6 scale were used. Respondents were asked the frequency of feeling (1) worthless, (2) nervous, (3) hopeless, (4) depressed, (5) restless or fidgety and (6) that everything was an effort in the last 30 days ($\alpha = 0.84$, test-retest $r = 0.79$).	1, *all of the time;* 2, *most of the time*; 3, *some of the time;* 4, *a little of the time*; 5, *none of the time.*	Items were averaged, where lower scores reflected higher mental health symptomology.
Years lived in the neighbourhood.	PMK self-reports from the 2014 OCHS on the number of years they have lived in their current neighbourhood were used: 'How many years have you lived at this address?'		Used as a continuous variable.
Neighbourhood-level			
Residency	Based on the population density and size of the census subdivision the PMK reported (Statistics Canada, 2017b).		Coded as a (1) large urban centre (population 100,000 or greater), (2) small-medium centre (population 1,000 to 99, 999), or (3) rural area.
Neighbourhood Antisocial Behaviour	PMK self-reports on 4-items were used to create a cumulative risk score. Questions asked the PMK's about any household members personal experience with (1) assault, (2) repeated verbal insult or disrespect, (3) theft from household property or (4) household break-in. The neighbourhood anti-social behaviour scale was shown to have excellent test re-test reliability (Pearson's r = 0.72; Boyle et al., 2019a)	0, *no*; 1, *yes*.	Items were summed for each family. The average of all families within a neighbourhood was used (Boyle et al., 2019a).

Note: PMK= Person Most Knowledgeable.

3.9. Data Analyses

3.9.1. Missing Data Analyses

Of a total of 4,428 individuals, 19.8% of participants were missing one or more of the variables in the current study. For the outcome variables, missing data analysis revealed missing data on one or more of the sleep variables (12.3% of participants) was related to lower parent education, higher internalizing problems and higher levels of externalizing problems (See Appendix E). Chi-squared analyses between missing sleep outcomes did not show significant relationships to missingness with the number of parents in the household, family-level SEC, residency, medical condition, or sex. Participants were excluded (n = 546) from the final sample (N= 3, 882) if they had one or more sleep outcomes missing. Each predictor in the sample had a small proportion of missing data (less than 5% overall) and Full Information Maximum Likelihood (FIML) was used for predictors with missing data.

3.9.2. Multi-level Regression Models.

FIML with robust standard errors was used to estimate parameters in the models using MPlus (version 8.5). Sampling weights based on the probability of being selected and participating in the study created by Statistics Canada were applied to adolescents, between households and between neighbourhoods. Weighted data are presented for all descriptives.

Multi-level regression models were used in the current study, as adolescents were nested within families (level 2) and neighbourhoods (level 3) in the sampling design. In line with the study objectives, variables were centered in two ways in the models to aid in interpretation and reduce multicollinearity (Enders & Tofighi, 2007). 1) Child age, internalizing problems, externalizing problems, negative parenting behaviours, PMK depression, parent education and years lived in the neighbourhood were all grand-mean centered; that is, the sample mean was subtracted from each participant's score. 2) family-level poverty was group-mean centered; that is, the mean poverty status for each neighbourhood was subtracted from each participant's poverty score. We aimed to compare individuals' poverty status to the poverty in their neighbourhood via the cross-

level interaction, which included group-mean centered family poverty. Investigating the relationship of lower-level variables (i.e., family) by cluster (i.e., neighbourhood) is best achieved using group-mean centering in an interaction term, as within and between cluster relationships are parsed apart with group-mean centering (Enders & Tofighi, 2007). Thus, group-mean centered coefficients can be thought of as representing an individual's poverty status in relation to their neighbourhood. We included other child- and family-level variables in the models as covariates. The aim of their inclusion was to control for their relationships to sleep outcomes, not to investigate the relationship of these covariates by neighbourhood cluster. Grand-mean centering is suited for investigating the relationship between lower-level (i.e., child, family) variables without considering higher-level cluster variables (i.e., family cluster, neighbourhood cluster); grand-mean centering does not parse apart within and between cluster relationships (Enders & Tofighi, 2007). Thus, grand-mean centered coefficients can be thought of as representing individuals' scores in relation to all participants in the sample (Curran & Bauer, 2021).

A five-step model-building approach was used to assess the relationship of the predictors on the sleep outcome variables above and beyond the control variables in the current study. (1) An intercept-only model was used to examine the variation in adolescent sleep problems and duration explained by family and neighbourhood clusters. (2) Adolescent-level control variables (i.e., age, sex, chronic illness, negative parenting internalizing and externalizing problems) and then (3) family-level SES (i.e., education and family poverty) and control predictors (i.e., parent mental health symptomology, marital status, years lived in the neighbourhood, education level) were added. (4) The random effects for family poverty were tested, to examine if family poverty varied by neighbourhood. (5) Neighbourhood-level SES and neighbourhood-level control variables (i.e., residency, antisocial behaviour, poverty level) were then added to the model. (6) Finally, the cross-level interaction between family poverty and neighbourhood-level poverty was included to test the association of relative economic disparity on the sleep outcomes, as per hypothesis one.

Family-level poverty was included in step four as a random effect. Random effects allow for the coefficients and slopes of variables to vary between neighbourhoods

(Finch & Bolin, 2017). Significant relationships would indicate family poverty varied by neighbourhood, suggesting a significant cross-level interaction may exist. The Inter-class correlation (ICC) was calculated at the final step to show how much variance in the model was explained at the neighbourhood-level, family-level and families nested in neighbourhoods (Lorah, 2018).

3.10. Results

The sample was 51.40% male with a mean age of 14.51 (SD = 1.68; range 12 to 17). Households included in this study were primarily two-parent households (78.2%), educated (45.7% had a bachelor's degree or above) and 79.7% of the sample had a family income above the low-income cut-off. Weighted prevalence estimates and descriptives of continuous variables are presented in Table 7.

Table 8. Weighted prevalences and descriptives of youth sleep outcomes, predictors and demographics

Variable	M (SD)	Range or %
Sleep Outcomes		
Weekday sleep duration	7.85 (1.23)	4-13
Less than 8 hours		10.44%
9.0-9.9 hours		26.97%
10.0-10.9 hours		44.37%
11.0+ hours		18.27%
Weekend sleep duration	8.94 (1.57)	4-13
Less than 8 hours		11.31%
9.0-9.9 hours		24.36%
10.0-10.9 hours		40.0%
11.0+ hours		23.49%
Problems staying asleep	2.90 (1.95)	0-8
Problems falling asleep	2.62 (0.93)	1-4
I fall asleep very quickly; less than 5 minutes		11.7%
A few minutes; 5-10 minutes		33.6%
A little while; 11-30 minutes		35.4%
A long time; more than 30 minutes		19.2%
Predictors		
Child-level		
Age	14.51 (1.68)	12-17
Sex		0-1
Male		51.7%
Female		48.0%
Internalizing problems	0.22 (0.33)	0-2
Externalizing problems	0.27 (0.25)	0-2
Chronic Illness		0-1
With chronic illness		30.9%

No chronic illness		69.3%
Negative parenting	1.07 (0.68)	1-5
Family-level		
Marital Status		0-1
Two-parent family		78.2%
Single parent family		22.0%
Parent mental health symptomology	0.54 (0.62)	0-4
Years lived in the neighbourhood	11.76 (7.97)	0-57
Family poverty		0-1
Family poverty		79.7%
No family poverty		20.3%
Highest parent education		
Less than a Bachelor degree[1]		53.4%
A Bachelor's degree		29.9%
Above a Bachelor's degree		15.8%
Neighbourhood-level		
Residency	2.66 (0.67)	0-3
Rural		13.8%
Small/medium urban		13.3%
Large urban		72.9%
Neighbourhood poverty	13.33 (12.44)	0-73.4
Neighbourhood antisocial behaviour	0.57 (0.62)	0-4
Demographics		
Ethnicity		
White		66.2%
Other[2]		35.3%
Income		
<74,999		38.2%
75,000-1,999,999		46.8%
>2,000,000		13.5%

Note: N= 3,882; Each child was weighted based on the probability of being selected for the study. M (SD) = Mean (Standard deviation).

[1] = due to vetting guidelines at the research data centre (RDC) the following groups had to be aggregated: Grade 8 or lower; grade 9-10; grade 11-12 not completed; secondary school completed; trade certificate/diploma; college, CEGEP or other non-university certificates/diplomas; university certificate below the bachelor's level.

[2] = due to vetting guidelines at the RDC the following groups had to be aggregated: Chinese, Black, Filipino, Latin American, Arab, Southeast Asian, West Asian, Korean, Japanese, Other.

3.9.3. Predicting Adolescent Sleep Outcomes.

Results from the final step of the analyses of the adolescent data are presented in Tables 8 and 9. Full results for each step of the model for each outcome are presented in Appendix F. The significance for each block/step in the model is summarized, followed by a description of the significant predictors from the final step of the model.

Problems Falling Asleep. At the adolescent-level, only two predictors were significant: internalizing problems and chronic illness. At the family-level, only the years lived in the neighbourhood variable was significant. Including family poverty as a random effect was non-significant. This suggests the impact of family poverty on sleep outcomes does not vary across neighbourhoods. When adding neighbourhood-level variables, only neighbourhood poverty was significant. Finally, after adding the cross-level interactions (family x neighbourhood), none of the interactions were significant and neighbourhood-level poverty was no longer significant.

The ICCs of the final model showed 12.39% of the variance in problems falling asleep were accounted for at the neighbourhood-level, 5.41% of the variance at the family-level and 17.57% at the level of families nested within neighbourhoods (family x neighbourhood interaction).

Higher levels of internalizing (ß = 0.83) and having one or more chronic illnesses (ß = 0.09) predicted significantly more problems falling asleep at the adolescent-level (see Table 8). At the family-level, longer time living in the neighbourhood (ß = 0.01) predicted more problems falling asleep.

Problems Staying Asleep. The problems staying asleep models showed that four of six adolescent-level predictors were significant at that level. When the family-level predictors were added as fixed effects, all of the predictors at the family-level were non-significant and at the child-level chronic condition was no longer a significant predictor. When the family-level poverty was included as a random effect it was non-significant. When the neighborhood-level predictors were included, neighbourhood poverty and antisocial behaviour were significant. In the final step, the cross-level interactions (family x neighbourhood) were non-significant, and the relationship of family-level poverty became significant on this step.

The ICCs of the final model showed 10.65% of the variance in problems staying asleep were accounted for at the neighbourhood-level, 2.90% of the variance at the family-level and 13.55% at the level of families nested within neighbourhoods.

Higher levels of internalizing problems (ß = 2.01) and being male (ß = 0.17) significantly predicted more problems staying asleep at the adolescent-level. At the neighbourhood level, higher levels of neighbourhood poverty (ß = 0.18) and lower levels of neighbourhood antisocial violence (ß = -0.01) predicted increased problems staying asleep. Family-level poverty was also significant (ß = -0.05), suggesting that the relationship of family-level poverty on problems staying asleep varied based on neighbourhood.

Weekday Sleep Duration. For the weekday sleep duration, the model building showed only three significant adolescent-level variables (described below). At the family-level all variables were non-significant; family-level poverty as a random effect was also non-significant. However, when adding family poverty as a random effect, negative parenting was no longer significant in this step of the model. When adding the neighbourhood-level variables the model showed no significant neighbourhood-level predictors, but negative parenting became a significant predictor for all remaining models again. The cross-level interaction (family x neighbourhood) was non-significant in the final step of the model.

The ICCs of the final model showed 17.57% of the variance in weekday sleep duration was accounted for at the neighbourhood-level, 29.73% of the variance at the family-level and 47.30% at the level of families nested within neighbourhoods.

Older youth (ß = -0.28), higher levels of internalizing problems (ß = -0.84) and higher levels of negative parenting behaviours (ß = -0.08) predicted significantly shorter sleep duration (see Table 5).

Weekend Sleep Duration. The weekend sleep duration model building showed two significant adolescent-level predictors and when at the family-level, parent education level significantly predicted weekend sleep duration. Family-level poverty as a random effect was non-significant, as were all of the neighbourhood-level predictors and the cross-level interactions (family x neighbourhood).

The ICCs of the final model showed 5.02% of the variance in weekend sleep duration was accounted for at the neighbourhood-level, 9.40% of the variance at the family-level and 14.42% at the level of families nested within neighbourhoods.

Older youth (ß = -0.10) and higher levels of internalizing problems (ß = -0.44) significantly predicted longer sleep durations on weekends at the child-level. At the family-level, lower levels of parent education (ß = 0.06) significantly predicted shorter sleep duration on weekends.

Table 9. Fixed effects and random effects for multilevel models of youth sleep problems.

	Unconditional				Model 6			
	Problems falling asleep		Problems staying asleep		Problems falling asleep		Problems staying asleep	
	ß	(SE)	ß	(SE)	ß	(SE)	ß	(SE)
Fixed effects								
Intercept	2.62***	(0.02)	2.93***	(0.04)	2.74***	(0.07)	3.26***	(0.15)
Level 1: Youth								
Age (in years)					-0.01	(0.01)	-0.01	(0.02)
Sex (1 = male)					0.01	(0.04)	0.17*	(0.07)
Internalizing Problems[a]					0.83***	(0.05)	2.01***	(0.12)
Externalizing Problems[b]					0.09	(0.09)	0.16	(0.19)
Chronic Illness (1 = one or more chronic illness)					0.09*	(0.04)	0.11	(0.08)
Negative Parenting[c]					0.02	(0.03)	0.10	(0.06)
Level 2: Families								
PMK Marital status (1 = single parent family)					-0.05	(0.05)	-0.06	(0.10)
PMK Mental Health Symptomology[d]					0.02	(0.03)	-0.01	(0.06)
Years Lived in Neighbourhood[e]					0.01*	(0.00)	0.00	(0.01)
Education Level[f]					-0.02	(0.01)	-0.01	(0.02)
Level 3: Neighbourhoods								
Residency[g]					-0.04	(0.03)	-0.09	(0.05)
Neighbourhood-level Poverty[h]					-0.00	(0.00)	0.18*	(0.07)
Neighbourhood Antisocial Behaviour[i]					0.04	(0.04)	-0.01*	(0.00)
Cross-Level Interaction								

Family-level Income Measure x Neighbourhood-level Poverty					0.01	(0.01)	0.01	(0.01)
Random effects								
Level 1: Youth	0.68***	(0.04)	3.15***	(0.16)	0.61***	(0.04)	2.68***	(0.15)
Level 2: Families	0.06	(0.04)	0.10	(0.15)	0.04	(0.03)	0.09	(0.14)
Level 3: Neighbourhoods	0.13***	(0.02)	0.58***	(0.82)	0.09***	(0.02)	0.33***	(0.07)
Family-level poverty					-0.04	(0.09)	-0.05***	(0.80)
Model summary								
Deviance statistic	17353.19		15919.32		8957.55		14050.26	
Number of estimated parameters	4		4		21		21	

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. PMK = Person Most Knowledgeable Some Betas were rounded to .00, but ranged from 0.001 to 0.004.

[a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.

Table 10. Fixed effects and random effects for multilevel models of youth sleep durations.

	Unconditional				Model 6			
	Weekday sleep duration		Weekend sleep duration		Weekday sleep duration		Weekend sleep duration	
	ß	(SE)	ß	(SE)	ß	(SE)	ß	(SE)
Fixed effects								
Intercept	7.86***	(0.02)	8.95***	(0.03)	7.83***	(0.09)	9.15***	(0.11)
Level 1: Youth								
Age (in years)					-0.29***	(0.01)	-0.10***	(0.02)
Sex (1 = male)					0.08	(0.04)	-0.10	(0.06)
Internalizing Problems[a]					-0.84***	(0.07)	-0.44***	(0.10)
Externalizing Problems[b]					0.09	(0.11)	-0.04	(0.15)
Chronic Illness (1 = one or more chronic illness)					0.02	(0.05)	0.09	(0.06)
Negative Parenting[c]					-0.09*	(0.04)	-0.04	(0.05)
Level 2: Families								
PMK Marital status (1 = single parent family)					-0.07	(0.06)	-0.07	(0.08)
PMK Mental Health Symptomology[d]					0.02	(0.04)	0.01	(0.05)
Years Lived in Neighbourhood[e]					0.00	(0.00)	0.00	(0.00)
Education Level[f]					-0.01	(0.01)	0.07***	(0.02)
Level 3: Neighbourhoods								
Residency[g]					0.02	(0.03)	-0.05	(0.04)
Neighbourhood-level Poverty[h]					-0.00	(0.00)	-0.01	(0.00)
Neighbourhood Antisocial Behaviour[i]					-0.02	(0.05)	0.01	(0.06)
Cross-Level Interaction								

Family-level Income Measure x Neighbourhood-level Poverty					-0.00	(0.01)	0.00	(0.01)
Random effects								
Level 1: Youth	1.22***	(0.07)	1.98***	(0.12)	0.92***	(0.06)	1.81***	(0.10)
Level 2: Families	0.09	(0.05)	0.23*	(0.11)	0.07	(0.04)	0.16	(0.10)
Level 3: Neighbourhoods	0.21***	(0.03)	0.28***	(0.05)	0.14***	(0.52)	0.24***	(0.05)
Family-level Income Measure Random Effect					-0.11	(0.13)	-0.23	(0.20)
Model summary								
Deviance statistic	16690.02		14286.60		10450.46		12883.50	
Number of estimated parameters	4		4		21		21	

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. PMK = Person Most Knowledgeable Some Betas were rounded to .00, but ranged from 0.001 to 0.004.

[a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.

3.11. Discussion

There were three novel findings in the current study. (1) Residency (rural to urban), included as an exploratory variable, was non-significant for all sleep outcomes. (2) Number of years lived in the neighbourhood was significantly related to more problems falling asleep. (3) Lower neighbourhood antisocial behaviour was related to higher problems staying asleep. A discussion of the main variables of interest will be included in the following order: (1) neighbourhood antisocial behaviour, (2) socio-economic status, (3) the interaction between neighbourhood and family poverty, (4) child-level predictors and (5) family-level predictors. Then we discuss the limitations and future research directions in this area.

3.11.1 Neighbourhood Anti-Social Behaviour

The relationship between neighbourhood antisocial behaviour and problems staying asleep was not as predicted. *Lower* levels of neighbourhood-antisocial behaviour predicted *higher* levels of problems staying asleep. These results differ from the literature, as other studies have found positive associations between sleep problems and neighbourhoods safety or exposure to community violence (Mayne et al., 2021a). It is possible that the proximal relationship of neighbourhood antisocial violence was not as salient in adolescents in the current sample as in previous studies. This may be because the average antisocial behaviour for each neighbourhood was used, unlike other studies which have used the direct experience of community violence or self-reported neighbourhood safety. Additionally, most of the research on neighbourhood safety has been completed in samples from the United States. There may be differences in the saliency of neighbourhood safety or exposure to violence in Canadian samples. For example, the United States may have a higher violent crime rate, while Canada may have higher rates of property crime (Gannon, 2001), and these differences may have important associations to adolescent sleep outcomes. Direct experience with violent crime, used in previous research, may have a stronger more direct relationship to adolescent sleep than average levels of antisocial behaviour (i.e., break-ins, stolen property, verbal disrespect,

assault). Future research should investigate if the direct experiences of youth in their neighbourhood are related to sleep outcomes more so than more objective measures. Future research is needed to see if this relationship is replicated in other Canadian samples.

3.11.2. Neighbourhood Factors

Interestingly, the only sleep outcome significantly predicted by neighbourhood-level factors was problems staying asleep. It may be that high poverty neighbourhoods have higher noise levels (e.g., emergency vehicle sirens) which might contribute to more night wakings. For problems falling asleep, it may be that mechanisms in the neighbourhood are not as salient. Future research should replicate these findings in other samples and identify the mechanisms that may be interfering more in problems staying asleep than problems falling asleep. Weekday sleep duration had the highest ICC of all the models, explaining 47.03% of the variance at the families nested within neighbourhood level. Other outcomes explained variance at the families nested within neighbourhood level between 13.55% (problems staying asleep) and 17.57% (problems falling asleep). The higher explained variance of weekday sleep duration may be due to the scheduled nature of weekdays and in particular school start time. That is, children within the same neighbourhood likely have similar travel times for school.

3.11.3. The Contribution of SEC to Adolescent Sleep

Higher neighbourhood-level poverty significantly predicted more problems staying asleep in adolescents. This is a novel finding. Other studies have not assessed the relationship between neighbourhood-level poverty and problems staying asleep in adolescents (Rubens et al., 2016; Troxel et al., 2017). While research on other neighbourhood exposures has been done (e.g., availability of amenities, pollution levels), no research to date has investigated how these exposures may mediate this relationship. Future research should focus on the relationship between adolescent problems staying asleep, neighbourhood poverty and the mechanisms that may be driving this relationship.

The current study found non-significant relationships between neighbourhood poverty and problems falling asleep, weekday sleep duration and weekend sleep duration. No other studies to date have assessed falling asleep and staying asleep separately in a

sample of adolescents; previous studies have assessed problems falling asleep and used measures of general sleep problems (Moore et al., 2011; Rubens et al., 2020; Troxel et al., 2017). Other researchers have proposed this may be the result of neighbourhood SEC being related differentially to sleep outcomes through different causal processes (El-Sheikh et al., 2013).

3.11.4. Relative Economic Position and Youth Sleep Outcomes

The interaction of family-level x neighbourhood-level poverty was non-significant for all sleep outcomes in the study. In contrast, in analyses of the 2014-OCHS data for children (age 4 to 12), there was a significant family-level x neighbourhood poverty for weekend sleep duration (see Chapter 2). The non-significant interaction for adolescents could be the result of two issues. (1) The interaction between family and neighbourhood poverty may not be as developmentally relevant in adolescence, compared to childhood. For example, adolescents living in high poverty neighbourhoods may habituate to the noise level of their neighbourhoods over time. (2) We may not have found a statistically significant interaction due to low power, as the interaction term was included after controlling for child-, family, and neighbourhood-level variables. Therefore, future research should investigate this relationship with larger sample sizes.

3.11.5. Adolescent-level Predictors

Older age predicted significantly shorter sleep durations, which is consistent with both observed shorter sleep durations among older adolescents and the recommended sleep duration guidelines (Gregory & O'Connor, 2002; Paruthi et al., 2016). This reduction in sleep durations is due to a circadian timing phase delay and the slowing of sleep pressure build-up, which both occur during adolescence (Carskadon, 2011). In this study, 19.32% of youth slept 8 hours or less on weekends and 45.08% slept less than 8 hours on weekdays. This is similar to the National Sleep Foundation 2006 results, which found 45% of adolescents slept less than 8 hours on weekdays and 17% of adolescents got less than 8 hours of sleep on weekends (National Sleep Foundation, 2006). Therefore, the current study had similar sleep durations on weekdays and weekends to a national sample from the United States.

Higher levels of internalizing problems significantly predicted more sleep problems and lower sleep durations in all outcomes. This is consistent with previous research (Gregory & O'Connor, 2002; Nunes et al., 2020; Quach et al., 2018). A number of studies have shown that internalizing problems concurrently predict sleep problems and longitudinal studies show child sleep problems predict later internalizing problems in adolescence (see review by Becker et al., 2017). Psychological disorders may have shared etiologic features with sleep outcomes in three ways (Harvey et al., 2011). (1) the association between sleep and emotional dysregulation, (2) association between psychological disorders and circadian genes and (3) association between dopamine and serotonin systems with sleep outcomes and psychological disorders (Harvey et al., 2011). Of note, only three studies to date have included a mental health-related variable while investigating the relationship between neighbourhood factors and adolescent sleep outcomes (Marco et al., 2012; Moore et al., 2011; Troxel et al., 2017). The results of the current study show internalizing problems in particular is an important adolescent-level variable to control for, as higher levels of internalizing problems significantly predicted more sleep problems and lower sleep durations in all models.

3.11.6. Family-level Predictors

Lower parent education level was related to lower weekend sleep duration in adolescents. This is consistent with research that has found lower maternal education is related to shorter sleep duration (Bøe et al., 2012). The relationship between parent education and lower sleep duration is thought to be the result of reduced use of bedtime routines; that is, parents with a lower education level may not use bedtime routines as consistently as parents with a higher education level (Bøe et al., 2012). Adolescents living in lower SES households may also have to wake earlier on weekends to work. A study by Dorofaeff and Denny (2006) found adolescent employment was related to shorter sleep durations overall. Future research should investigate the role of youth employment and family education level with adolescent sleep duration. In families where the family income fell below the low-income cut-off, adolescents had more problems staying asleep. Troxel et al. (2017) proposed that low SES families have more disorganized homes and less sleep hygiene knowledge which fosters poor sleep hygiene in adolescents. This could lead to more frequent night waking.

The number of years the family had lived in the neighbourhood was related to higher problems staying asleep. This finding may have to do with the length of time adolescents have been exposed to their neighbourhoods. Specifically, this relationship may be driven by neighbourhood characteristics related to safety or pollution. For example, long exposure to neighbourhoods with high levels of air pollution may cause adolescents to develop health problems that make staying asleep more difficult (e.g., coughing due to lung damage; Kannan et al., 2017). Length of exposure to unsafe neighbourhoods may also play a role in this relationship as well. Future research should investigate the number of years lived in a neighbourhood as a potential moderator for neighbourhood-level factors and adolescent sleep outcomes.

3.11.7. Implications for Adolescent Sleep Health

The results of the current study show that high neighbourhood poverty predicts more problems staying asleep in adolescents above and beyond well-established risk factors. Specifically, adolescents living in high poverty neighbourhoods may have more problems staying asleep. There are three potential implications. First, clinicians should keep neighbourhood-level SEC in mind when considering aspects that may be contributing to sleep problems in adolescence. Second, the results of the current study show the importance of prioritizing investments into high poverty neighbourhoods. Third, the results of the current study showed neighbourhood-level factors were related to problems staying asleep, so clinicians should consider interventions that reduce the effects of neighbourhood factors from interfering in sleep (e.g., using a fan for background noise).

3.11.8. Limitations

There are also some important limitations to consider in the current study. First, the low-income measure used does not account for the cost of living in the city the family lived. This may be an important consideration given the cost of living between rural and urban places may differ. We used the LIM to facilitate comparisons to other studies (Boyle, Georgiades, Duncan, Wang, et al., 2019; Comeau et al., 2021). Future studies should account for the cost of living in neighbourhood SEC. Second, the dissemination areas used in the current study are geographically larger for rural areas than urban areas. As such, “neighbourhoods” were not uniform across all individuals in this study. The

geographic size of the neighbourhood may interact with neighbourhood characteristics to impact sleep. Third, missing data analyses showed differences between individuals missing a sleep outcome and individuals with complete data on major predictor variables. This may play a role in the results of this study as low parent education was significantly related to missing a sleep outcome variable. As noted, 12.3% of the total sample was missing one or more sleep outcomes. Therefore, the sample may be missing meaningful sleep outcome data for adolescents who live in high poverty neighbourhoods, and if these were youth who also had sleep problems, the relationship between neighbourhood poverty on sleep would be underestimated. Fourth, this study used self-reports for all data, so shared method variance may be playing a role in findings. Fifth, this study did not investigate differences in sleep outcomes by ethnicity, which has been identified as a moderating variable in the relationship between parent education level and adolescent sleep outcomes. Sixth, the residency variable used was a categorical variable; therefore, more sensitive measures of population density should be investigated in the future. Finally, the cross-sectional design of the study did not allow us to look at causal relationships between the variables. Future research should aim to use longitudinal studies, natural experiments or quasi-experimental designs which could strengthen causal inferences between neighbourhood factors and sleep outcomes.

Summary and Future Research: The results of the current study show internalizing problems emerged as an important predictor in all sleep outcomes and should be included in future studies investigating neighbourhood factors and child sleep outcomes. The findings from this study suggest neighbourhood factors may have unique relationships to specific sleep outcomes (e.g., neighbourhood antisocial behaviour and neighbourhood poverty with problems staying asleep) future research should investigate the mechanisms between neighbourhood-level factors and sleep outcomes.

Appendix D: Correlations between youth sleep outcomes

Table D.1. Correlation matrix between youth sleep outcome variables.

	Problems Falling Asleep	Problems Staying Asleep	Weekday Sleep Duration
Problems Falling Asleep			
Problems Staying Asleep	.35**		
Weekday Sleep Duration	-.18**	-.17**	
Weekend Sleep Duration	-.06**	-.14**	.30**

Note: N= 3,882; ** = p <.01; All correlations weighted by the probability of the child being selected for the study.

Appendix E: T-tests of Missing A Youth Sleep Outcome Variable

Table E.1. T-tests for youth missing data

Variable	t	Cohen's d
Predictors		
Child-level		
Age	1.59	.07
Sex[1]		
Internalizing problems	1.98**	.32
Externalizing problems	5.02***	.30
Chronic Illness[1]		
Negative parenting	-1.25	-.06
Family-level		
Marital Status[1]		
Parent mental health symptomology	0.81	.04
Years lived in the neighbourhood	1.60	.09
Family poverty[1]		
Highest parent education	-3.65***	-.18
Neighbourhood-level		
Residency[1]		
Neighbourhood poverty	-0.91	-.04
Neighbourhood antisocial behaviour	1.87	.09

Note: Groups were coded as: 0 = data for all four sleep outcome (n=3,882); 1 = one or more missing sleep outcomes (n=546); M = mean. SE= Standard Error; This table is weighted by the child's probability of being selected for the study.

All t-tests compared the missingness of a sleep outcome to each variable. [1] = Due to vetting guidelines degrees of freedom and mean differences could not be released. Chi-squared analyses for nominal data revealed no significant differences based on groups with and without missing data, but could not be released as they did not meet the minimum cell count.

Appendix F: Full tables of all steps of multi-level models for youth sleep outcomes

Table F.1

Full fixed and random effects for multilevel models of youth problems staying asleep outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	1.45 (0.02)***	2.91*** (0.04)	3.01*** (0.06)	3.01*** (0.06)	3.27*** (0.14)	3.26*** (0.15)
Level 1: Children						
Age (in years)		-0.00 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Sex (1 = male)		-0.16* (0.04)	-0.16* (0.07)	-0.17* (0.07)	-0.17* (0.07)	0.17* (0.07)
Internalizing Problems[a]		2.01*** (0.12)	2.03*** (0.12)	2.02*** (0.12)	2.01*** (0.12)	2.01*** (0.12)
Externalizing Problems[b]		0.28 (0.18)	0.21 (0.18)	0.23 (0.19)	0.16 (0.19)	0.16 (0.19)
Chronic Illness (1 = one or more chronic illness)		0.15* (0.08)	0.13 (0.08)	0.12 (0.08)	0.10 (0.08)	0.11 (0.08)
Negative Parenting[c]		0.11* (0.05)	0.11* (0.06)	0.11* (0.06)	0.10 (0.06)	0.10 (0.06)
Level 2: Families						

PMK Marital status (1 = single parent family)			-0.08 (0.10)	-0.09 (0.10)	-0.06 (0.10)	-0.06 (0.10)
PMK Mental Health Symptomology[d]			0.00 (0.06)	-0.01 (0.06)	-0.01 (0.06)	-0.01 (0.06)
Years Lived in Neighbourhood[e]			0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Education Level[f]			-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)
Family-level poverty (1 = below LIM)			0.11 (0.14)			
Level 3: Neighbourhoods						
Residency[g]					-0.09 (0.05)	-0.09 (0.05)
Neighbourhood-level Poverty[h]					-0.01** (0.00)	-0.01* (0.003)
Neighbourhood Antisocial Behaviour[i]					0.18** (0.07)	0.18* (0.07)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.01 (0.01)
Random effects						
Level 1: Children	1.05*** (0.05)	2.74*** (0.15)	2.74*** (0.15)	2.68*** (0.15)	2.68*** (0.15)	2.68*** (0.14)
Level 2: Families	0.02 (0.05)	0.09 (0.14)	0.10 (0.14)	0.09 (0.14)	0.09 (0.14)	0.09 (0.14)
Level 3: Neighbourhoods	0.15*** (0.03)	0.40*** (0.07)	0.40*** (0.07)	0.36*** (0.07)	0.33*** (0.07)	0.33*** (0.07)
Family-level poverty random effect				0.11 (0.13)	0.09 (0.13)	-0.05*** (0.80)
Model summary						
Deviance statistic	11573.81	15072.41	14248.00	14228.52	14051.01	14050.26

Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.LIM= Low-income Measure.

Table F.2

Full fixed and random effects for multilevel models of youth problems falling asleep outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	2.62*** (0.02)	2.62*** (0.02)	2.61*** (0.03)	2.61*** (0.03)	2.74*** (0.07)	2.74*** (0.07)
Level 1: Children						
Age (in years)		-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Sex (1 = male)		0.02 (0.04)	0.02 (0.04)	0.01 (0.04)	0.01 (0.04)	0.01 (0.04)
Internalizing Problems[a]		0.83*** (0.05)	0.83*** (0.06)	0.83*** (0.05)	0.83*** (0.05)	0.83*** (0.05)
Externalizing Problems[b]		0.14 (0.08)	0.10 (0.09)	0.11 (0.09)	0.09 (0.09)	0.09 (0.09)
Chronic Illness (1 = one or more chronic illness)		0.11*** (0.04)	0.08* (0.04)	0.09* (0.04)	0.09* (0.04)	0.09* (0.04)
Negative Parenting[c]		0.03 (0.03)	0.03 (0.03)	0.02 (0.03)	0.02 (0.03)	0.02 (0.03)
Level 2: Families						
PMK Marital status (1 = single parent family)			-0.06 (0.04)	-0.06 (0.04)	-0.05 (0.05)	-0.05 (0.05)

PMK Mental Health Symptomology[d]			0.01 (0.03)	0.01 (0.03)	0.02 (0.03)	0.02 (0.03)
Years Lived in Neighbourhood[e]			0.01* (0.00)	0.01** (0.00)	0.01* (0.00)	0.01* (0.00)
Education Level[f]			-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)	-0.02 (0.01)
Family-level poverty (1 = below LIM)			0.08 (0.06)			
Level 3: Neighbourhoods						
Residency[g]					-0.05 (0.02)	-0.04 (0.02)
Neighbourhood-level Poverty[h]					-0.00* (0.00)	-0.00 (0.00)
Neighbourhood Antisocial Behaviour[i]					0.04 (0.04)	0.04 (0.04)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.01 (0.00)
Random effects						
Level 1: Children	0.68*** (0.04)	0.63*** (0.04)	0.63*** (0.04)	0.61*** (0.04)	0.61*** (0.04)	0.61*** (0.04)
Level 2: Families	0.05 (0.04)	0.04 (0.03)	0.03 (0.03)	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)
Level 3: Neighbourhoods	0.13*** (0.02)	0.11*** (0.02)	0.10*** (0.02)	0.09*** (0.02)	0.09*** (0.02)	0.09*** (0.02)
Family-level poverty random effect				0.06 (0.06)	-0.04 (0.09)	-0.04 (0.09)
Model summary						
Deviance statistic	17353.19	9644.23	9087.15	9076.49	8959.01	8957.55
Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. LIM= Low-income Measure.

Table F.3

Full fixed and random effects for multilevel models of youth weekday sleep duration outcome.

	Unconditional ß (SE)	Child-level Predictors: Fixed ß (SE)	Family-level predictors: Fixed ß (SE)	Family-level Predictors and Family-level income random effect ß (SE)	Neighbourhood-level predictors fixed ß (SE)	Interaction between Neighbourhood poverty and Family income ß (SE)
Fixed effects						
Intercept	7.86*** (0.02)	7.86*** (0.02)	7.82*** (0.04)	7.82*** (0.03)	7.83*** (0.09)	7.83*** (0.09)
Level 1: Children						
Age (in years)		-0.28*** (0.01)	-0.28*** (0.01)	-0.28*** (0.01)	-0.28*** (0.01)	-0.28*** (0.01)
Sex (1 = male)		0.07 (0.04)	0.08 (0.04)	0.08 (0.04)	0.08 (0.04)	0.08 (0.04)
Internalizing Problems[a]		-0.82*** (0.07)	-0.83*** (0.07)	-0.82*** (0.07)	-0.84*** (0.07)	-0.83*** (0.07)
Externalizing Problems[b]		0.03 (0.11)	0.07 (0.11)	0.07 (0.11)	0.09 (0.11)	0.09 (0.11)
Chronic Illness (1 = one or more chronic illness)		0.02 (0.05)	0.03 (0.05)	0.03 (0.05)	0.02 (0.05)	0.02 (0.05)
Negative Parenting[c]		-0.08* (0.04)	-0.08* (0.04)	-0.08 (0.04)	-0.08* (0.04)	-0.08* (0.04)
Level 2: Families						
PMK Marital status (1 = single parent family)			-0.09 (0.06)	-0.08 (0.06)	-0.07 (0.06)	-0.07 (0.06)

PMK Mental Health Symptomology[d]			0.01 (0.04)	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)
Years Lived in Neighbourhood[e]			0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Education Level[f]			-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Family-level poverty (1 = below LIM)			-0.12 (0.08)			
Level 3: Neighbourhoods						
Residency[g]					0.02 (0.03)	0.02 (0.03)
Neighbourhood-level Poverty[h]					-0.00 (0.00)	-0.00 (0.00)
Neighbourhood Antisocial Behaviour[i]					-0.02 (0.05)	-0.02 (0.05)
Cross-Level Interaction						
Family-level poverty measure x neighbourhood-level poverty						-0.00 (0.01)
Random effects						
Level 1: Children	1.22*** (0.06)	0.94*** (0.05)	0.94*** (0.06)	0.92*** (0.06)	0.92*** (0.06)	0.92*** (0.06)
Level 2: Families	0.09 (0.05)	0.08 (0.04)	0.07 (0.04)	0.06 (0.04)	0.07 (0.04)	0.07 (0.04)
Level 3: Neighbourhoods	0.21*** (0.03)	0.12*** (0.03)	0.15*** (0.03)	0.14*** (0.03)	0.14*** (0.03)	0.14*** (0.52)
Family-level poverty random effect				-0.13 (0.08)	-0.13 (0.08)	-0.10 (0.13)
Model summary						
Deviance statistic	16690.02	11222.30	10584.18	10557.93	10450.53	10450.46
Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4.LIM= Low-income Measure.

Table F.4

Full fixed and random effects for multilevel models of youth weekend sleep duration outcome.

	Unconditional	Child-level Predictors: Fixed	Family-level predictors: Fixed	Family-level Predictors and Family-level income random effect	Neighbourhood-level predictors fixed	Interaction between Neighbourhood poverty and Family income
	ß (SE)	ß (SE)	ß (SE)	ß (SE)	ß (SE)	ß (SE)
Fixed effects						
Intercept	8.94*** (0.03)	8.95*** (0.03)	8.97*** (0.05)	8.98*** (0.05)	9.15*** (0.11)	9.15*** (0.11)
Level 1: Children						
Age (in years)		-0.10*** (0.01)	-0.10*** (0.02)	-0.10*** (0.02)	-0.10*** (0.02)	-0.10*** (0.02)
Sex (1 = male)		-0.11 (0.06)	-0.10 (0.06)	-0.10 (0.06)	-0.10 (0.06)	-0.10 (0.06)
Internalizing Problems[a]		-0.39*** (0.10)	-0.41*** (0.10)	-0.43*** (0.10)	-0.43*** (0.10)	-0.44*** (0.10)
Externalizing Problems[b]		-0.17 (0.15)	-0.06 (0.15)	-0.07 (0.15)	-0.04 (0.15)	-0.04 (0.15)
Chronic Illness (1 = one or more chronic illness)		-0.04 (0.05)	0.10 (0.06)	0.10 (0.06)	0.09 (0.06)	0.09 (0.06)
Negative Parenting[c]			-0.04 (0.05)	-0.03 (0.05)	-0.04 (0.05)	-0.04 (0.05)
Level 2: Families						
PMK Marital status (1 = single parent family)			-0.08 (0.08)	-0.10 (0.08)	-0.07 (0.08)	-0.07 (0.08)
PMK Mental Health Symptomology[d]			-0.00 (0.05)	0.01 (0.05)	0.01 (0.05)	0.01 (0.05)
Years Lived in Neighbourhood[e]			0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Education Level[f]			0.07*** (0.02)	0.07*** (0.02)	0.06*** (0.02)	0.06*** (0.02)

Family-level poverty (1 = below LIM)			-0.17 (0.13)			
Level 3: Neighbourhoods						
Residency[g]					-0.05 (0.04)	-0.05 (0.04)
Neighbourhood-level Poverty[h]					-0.00 (0.00)	-0.00 (0.00)
Neighbourhood Antisocial Behaviour[i]					0.01 (0.06)	0.01 (0.06)
Cross-Level Interaction						
Family-level poverty x neighbourhood-level poverty						0.00 (0.01)
Random effects						
Level 1: Children	1.98*** (0.12)	1.88*** (0.11)	1.85*** (0.11)	1.80*** (0.10)	1.80*** (0.10)	1.80*** (0.10)
Level 2: Families	0.23* (0.11)	0.26** (0.11)	0.21* (0.10)	0.16 (0.10)	0.16 (0.10)	0.16 (0.10)
Level 3: Neighbourhoods	0.28*** (0.05)	0.27 *** (0.05)	0.28*** (0.05)	8.98*** (0.05)	0.24*** (0.05)	0.24*** (0.05)
Family-level poverty random effect				-0.22 (0.12)	-0.22 (0.12)	-0.23 (0.12)
Model summary						
Deviance statistic	14286.60	17505.39	13086.26	13031.83	12883.51	12883.50
Number of estimated parameters	4	10	15	17	20	21

Note: ***= p<.001, **= p<.01, *= p<.05; ß= unstandardized betas; SE= Standard errors. [a] = range from 0 to 2 ; [b] = range from 0 to 2; [c] = range from range 1 to 5; [d] = range 1 to 5; [e] = range from 0.0 to 57.0; [f] = range 1 to 9; [g] = range 0 (rural) to 3 (large urban); [h] = range from 0 to 73.4 ; [i] = range from 0 to 4. LIM= Low-income Measure.

Chapter 4

4. General Discussion

The primary aim of the current thesis was to investigate the relationship between neighbourhood-level factors (i.e., poverty, antisocial behaviour) and sleep outcomes in children and adolescents. We expected poorer neighbourhood factors would significantly predict adverse sleep outcomes in children and adolescents beyond well-established risk factors. The current thesis found a significant interaction between family and neighbourhood poverty on child weekend sleep duration. In addition, the child sample showed high neighbourhood poverty predicted more problems falling asleep. The youth sample showed lower neighbourhood poverty predicted more problems staying asleep. Three family-level predictors were significant predictors for youth sleep outcomes, but all family-level predictors were non-significant in the child sample. Finally, age and internalizing problems emerged as important predictors in all sleep outcomes across the two samples (See the child-level variables section below for a discussion of these two predictors).

This Chapter will review the results from both chapters 2 and 3 and discuss the following: (1) child and adolescent-level variables (henceforth referred to as child-level), (2) family-level variables, (3) neighbourhood-level variables. Similarities in findings across the samples will be discussed first, followed by a discussion of differences. Finally, recommendations for practice, policy, and research will be presented.

4.1. Child-level Variables

Higher levels of internalizing problems significantly predicted more sleep problems and lower sleep durations across both ages. First, it is important to stress that future research examining the unique relationship of specific variables on sleep issues should control for child internalizing problems. As noted in chapters 2 and 3, very few studies have controlled for child mental health problems and internalizing problems more specifically when examining neighbourhood factors. Longitudinal studies suggest anxiety and cognitive arousal may be driving the relationship between internalizing problems and sleep outcomes (Becker et al., 2017). In studies that have assessed anxiety and depression separately over time, sleep problems and generalized anxiety are observed to have a

bidirectional association. However, there is competing evidence on the bidirectionality of depression over time (Gregory & O'Connor, 2002). This relationship between anxiety and sleep problems is thought to be a result of increased problems getting to sleep and staying asleep due to pre-sleep cognitive arousal and hypervigilance (Becker et al., 2017). Cognitive arousal and hypervigilance is thought to cause the development of depression and anxiety and promote adverse sleep outcomes (Becker et al., 2017).

Age significantly predicted all sleep outcomes for children (aged 4 to 11) but only sleep durations (weekend and weekday) for adolescents. For sleep duration, these results follow the expected developmental trajectory of decreasing sleep durations as children age (Gregory & O'Connor, 2002; Paruthi et al., 2016). For sleep problems, these results support the idea that as children age there is spontaneous remission of sleep problems. This is likely due to an increased ability to sleep independently as children age (Mindell et al., 2006). In the adolescent models, age did not significantly predict sleep problems. This is consistent with research on the continuity of sleep problems over time (Gregory & O'Connor, 2002). Research has identified two courses of sleep problems in children and adolescence (Gregory & O'Connor, 2002). (1) Some children who take longer to sleep independently "grow out" of sleep problems as they age; (2) other children have persistent sleep problems across childhood and adolescents. As age did not predict sleep problems in youth, this suggests either that youth who have sleep problems are likely on the persistent course (Gregory & O'Connor, 2002), or that sleep problems may emerge at any point during adolescence.

These results may suggest that children and youth with chronic illnesses may struggle to fall asleep specifically. Previous research has focused on the assessment of sleep problems broadly (Sivertsen et al., 2009), but future research should assess if problems falling asleep are particularly salient for children and youth with chronic illness. Interestingly, research by Sivertsen and colleagues (2009) found the increased levels of sleep problems in children with chronic illness were accounted for by internalizing and externalizing problems. The authors proposed that the association was due to increased bedtime worry. Bedtime worry has been found to delay sleep onset (i.e., more problems falling asleep). Thus, future research should investigate if children with chronic illness

had increased problems falling asleep due to bedtime worry or if there is something characteristic of chronic illness in particular (i.e., pain that prevents sleep onset).

4.2. Family-level Variables

Contrary to our expectation, the family-level variables - poverty, parent marital status, parent mental health symptomology, number of years lived in the neighbourhood - only significantly predicted sleep outcomes in youth, but not in children. Family poverty predicted more problems staying asleep and lower parent education predicted shorter weekend sleep duration. Lower family SES might be related to weekend sleep duration and problems staying asleep in a number of ways. For example, adolescents in low SES homes may have to wake up early to work on weekends. However, our results for youth problems falling asleep and weekday sleep duration are inconsistent with findings that socio-economic status (SES) is a well-established risk factor for adolescent sleep (Felden et al., 2015). These non-significant relationships were unexpected in the current study and future research should investigate the possible moderators of this relationship between family-level SES and sleep outcomes. For example, some research has shown that lower SES is related to internalizing problems in adolescence (Letourneau et al., 2013). The current study may have found a non-significant relationship between family-SES and sleep outcomes because internalizing problems were accounted for in the model before family SES.

Our child sample results differed from other studies, which have found family-level SES to be significantly related to adverse sleep outcomes in children as well (Newton et al., 2020). There are a number of proposed mechanisms behind this relationship of family SES and sleep outcomes such as high-stress levels, reduced use of bedtime routines and working hours that prevent parents from being home during bedtime (El-Sheikh et al., 2013). The current study may not have found significant effects between SES and sleep outcomes for children for two reasons. 1) Many studies have found associations between SES and sleep outcomes in samples from the United States. The relationship between family SES and sleep outcomes may not be the same in Canadian samples, possibly due to the presence of different social programs for low-income individuals in Ontario. These social programs may reduce family stress levels and serve as a protective factor for child sleep outcomes. 2) The low-income measure- a

measure of relative poverty- was used in the current study. The relationship of family poverty on child sleep outcomes may operate with more adverse levels of poverty than the cut-offs used in the current study and this should be explored in future research.

4.3. Neighbourhood-level Variables

Neighbourhood-level factors were related differentially to sleep outcomes depending on children's age. Higher levels of neighbourhood antisocial behaviour predicted more problems falling asleep in children, while lower levels of antisocial behaviour predicted higher levels of problems staying asleep in youth. These different findings may be explained by three mechanisms. (1) This may be due to differences in the developmental importance of neighbourhood factors to sleep outcomes across age. For example, neighbourhood-level violence may be more influential in children who are still developing emotion regulation skills than in adolescence where more adaptive emotion regulation skills are used more frequently (Gullone et al., 2010). (2) Conversely, this could also be due to differences in the saliency of these factors between the samples. It is possible that adolescents are less likely to experience the neighbourhood antisocial behaviour their parents report due to increased independence. (3) Parent distress may mediate this relationship. Children may be more influenced by a parent who is distressed by neighbourhood antisocial behaviour, while adolescents who have better emotional regulation skills may be less influenced by parent distress. Future research should investigate the difference in youth versus parent perceptions of neighbourhood safety.

Higher neighbourhood poverty predicted lower weekday sleep duration in children, but more problems staying asleep in adolescence. This could be due to developmental differences in how neighbourhood poverty relates to sleep in children vs. adolescents. Other studies have found differences in the relationships between sleep outcomes within children samples, and youth samples (El-Sheikh et al., 2013; Troxel et al., 2017). However, no research to date has proposed which mechanisms may be responsible for these differing associations of neighbourhood SEC on different sleep outcomes. Thus, future research should aim to fill this gap. For example, investigating how neighbourhood pollution relates to children's abilities to fall and stay asleep may be important.

Neighbourhood residency (i.e., urban, rural) was significantly positively related to problems falling asleep and weekday sleep duration in children, but was non-significant in the youth sleep outcomes. Only three studies have investigated this relationship previously (Patte et al., 2017; Spruyt et al., 2005; Yang et al., 2009). The results of the current study are consistent with Spruyt et al., (2005) who found shorter sleep durations in urban children. However, the results are inconsistent with results from Yang and colleagues (2009), who found urban children had more sleep problems than rural children. This could be due to differences in the population density of cities/rural areas in China (Yang et al., 2009), versus Belgium (Spruyt et al., 2005), which may have more similar population densities to the sample used in the current study (i.e., Ontario).

The results of the current study differ for adolescents, of which previous research has found significant relationships to residency on adolescent sleep outcomes (Patte et al., 2017; Yang et al., 2009). Specifically, Patte et al., (2017) found rural and small urban adolescence had significantly longer sleep durations than their urban counterparts. The study by Yang et al., (2009) found urban preadolescents had significantly worse sleep outcomes. However, neither study previously controlled for child-level (i.e., chronic illness, internalizing problems) or family-level (i.e., parent education level) factors, which may have contributed to the difference in findings between the current study and previous studies. The mechanisms behind this relationship have yet to be explored, a gap that should be filled by future research.

Overall, the results of both samples suggest that neighbourhood-level factors may be particularly important in school-age children's (aged 4 to 11) sleep outcomes. These results may also suggest that different neighbourhood-level factors relate to sleep outcomes differentially at any age, and the relationship to sleep outcomes may change across development (Meltzer et al., 2021). Thus, age is important to consider in future studies examining neighbourhood effects on sleep.

Finally, we found a significant interaction between family and neighbourhood poverty for child weekend sleep duration, but the interaction was non-significant in youth. There are four explanations for this finding. (1) The youth sample was smaller (N= 3,882) than the child sample (N= 6,264); thus, this may have been a power issue in the youth sample. (2) the interactive relationship of family and neighbourhood poverty is

more important in childhood. Children who have problems sleeping independently are more affected by neighbourhood-level factors than adolescents who have learned to sleep independently. Further, the presence of family-level poverty compounds this relationship in children, possibly via lack of sleep hygiene knowledge. (3) Night wakings were based on parent-report; parents would only know if their child woke if the child called or went to their parent, or if they made sufficient noise that the parent was aware. For example, a child is woken by neighbourhood noise in the middle of the night. Additionally, children may have to wake up early on weekends due to parents work schedules. (4) Neighbourhood factors related to youth sleep outcomes differ from child sleep outcomes, due to adolescents' increased independence from their parents. For example, the relationship of family SES may be different from childhood to adolescence, as adolescents may have more control and independence over their sleep schedules. Future studies should replicate our results in children and youth samples and investigate these differing effects by age.

4.4. Implications for Child Sleep Health

Clinicians should keep neighbourhood SEC in mind when assessing contributing factors to sleep problems, as neighbourhood-level associations predicted sleep outcomes above and beyond well-established risk factors. For example, clinicians could ask if children are awoken due to noise in their neighbourhood. Probing for neighbourhood-level factors may enable interventions to be employed. For example, the use of a fan for white noise to mask environmental noise. The results of the current study also showed that neighbourhood associations were related to different outcomes in different ways across age. Specifically, neighbourhood antisocial behaviour was related to increased problems falling asleep for children, but lower problems staying asleep for adolescence. Thus, clinicians should consider how neighbourhood-level effects may be contributing to sleep problems based on a child's age. Overall, interventions that also target neighbourhood-level mechanisms for children in high poverty may be important additions to child sleep health.

4.5. Policy Implications

The results of both samples show the importance of investing in high poverty neighbourhoods to prevent further health inequities from developing. Sleep health is related to a number of important outcomes in childhood and adolescence (Gregory & O'Connor, 2002; Quach et al., 2018). Therefore, policy targeting inequities in sleep health may have wide-reaching effects. Though more research is needed, access to amenities in high poverty neighbourhoods may promote sleep health in children and adolescents (Feng et al., 2020; Testa, 2019).

In the child sample, the interaction of family x neighbourhood poverty showed children with family poverty living in low poverty neighbourhoods had the highest sleep durations on weekends. This may suggest that socio-economic mixing in neighbourhoods may have benefits for sleep health for children living in more affluent neighbourhoods. Currently, many municipal housing policies emphasize socio-economic mixing in neighbourhoods. The results of this study suggest policy-makers should continue to invest in policies that emphasize this, as it may have benefits for child weekend sleep duration.

4.6. Future Research

The results of the current study showed a number of important predictors at the child- and family-level. Future research should investigate if neighbourhood-level risk factors are related to child sleep problems the same way in children with and without these child- and family-level factors. For example, is the relationship between neighbourhood-level antisocial behaviour and sleep outcomes the same in children with internalizing problems as those without such problems? Future research should also investigate if there are different predictors of sleep problems in children with these risk factors. (e.g., do children with chronic illness have the same risk factors as children without chronic illness for sleep problems).

A number of previous studies have investigated sleep problems in samples from childhood and across adolescence (e.g., Olds et al., 2010; Rubens et al., 2020). The current study found differences in the associations of neighbourhood-level factors with child vs. adolescent sleep outcomes. This may suggest that the link between neighbourhood level factors and sleep outcomes differ across age. Therefore, future

research using child and adolescent participants should investigate age as a moderating variable in analyses.

4.7. Summary

Overall, the results between samples may suggest that neighbourhood-level factors may be related to sleep outcomes differentially within age groups and across development. Specifically, we found differences in which neighbourhoods variables were significant across age groups. To aid in our understanding of the developmental importance of neighbourhood-level variables, future research should assess these relationships longitudinally.

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